Instruction Manual

Model 510

Single-Channel Pulse Height Analyzer

Baird-Atomic, Inc.
Cambridge, Mass. USA

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SECTION I
GENERAL DESCRIPTION

1. INTRODUCTION.

The Atomic Instrument Company's single-channel Model 510 Pulse Height Analyzer is an instrument which generates an output signal if and only if an input pulse has an amplitude falling between two preset voltages. Only those pulses falling between the two amplitude levels set by the operator are passed through to the output for counting. Pulses of all other amplitudes are discarded. The difference between the two boundary voltages is called the channel width or window. The lower-level voltage is called the base line. The base line may be adjusted to any voltage between nearly zero and 100 volts and the channel width, from zero to seven volts.

2. PURPOSE OF EQUIPMENT.

Research in nuclear science has established the need for equipment capable of determining the pulse-amplitude spectrum of voltage pulses generated by nuclear-radiation detectors. The Model 510 is designed for high-resolution pulse-amplitude analysis where the number of measurements to be made is insufficient to justify purchase of a multi-channel analyzer such as the Model 520 Twenty-Channel Pulse Height Analyzer. When used with a linear or calibrated radiation detector, a linear amplifier, and a scaler or other counting device, the Model 510 permits determination of the energy distribution of nuclear particles.

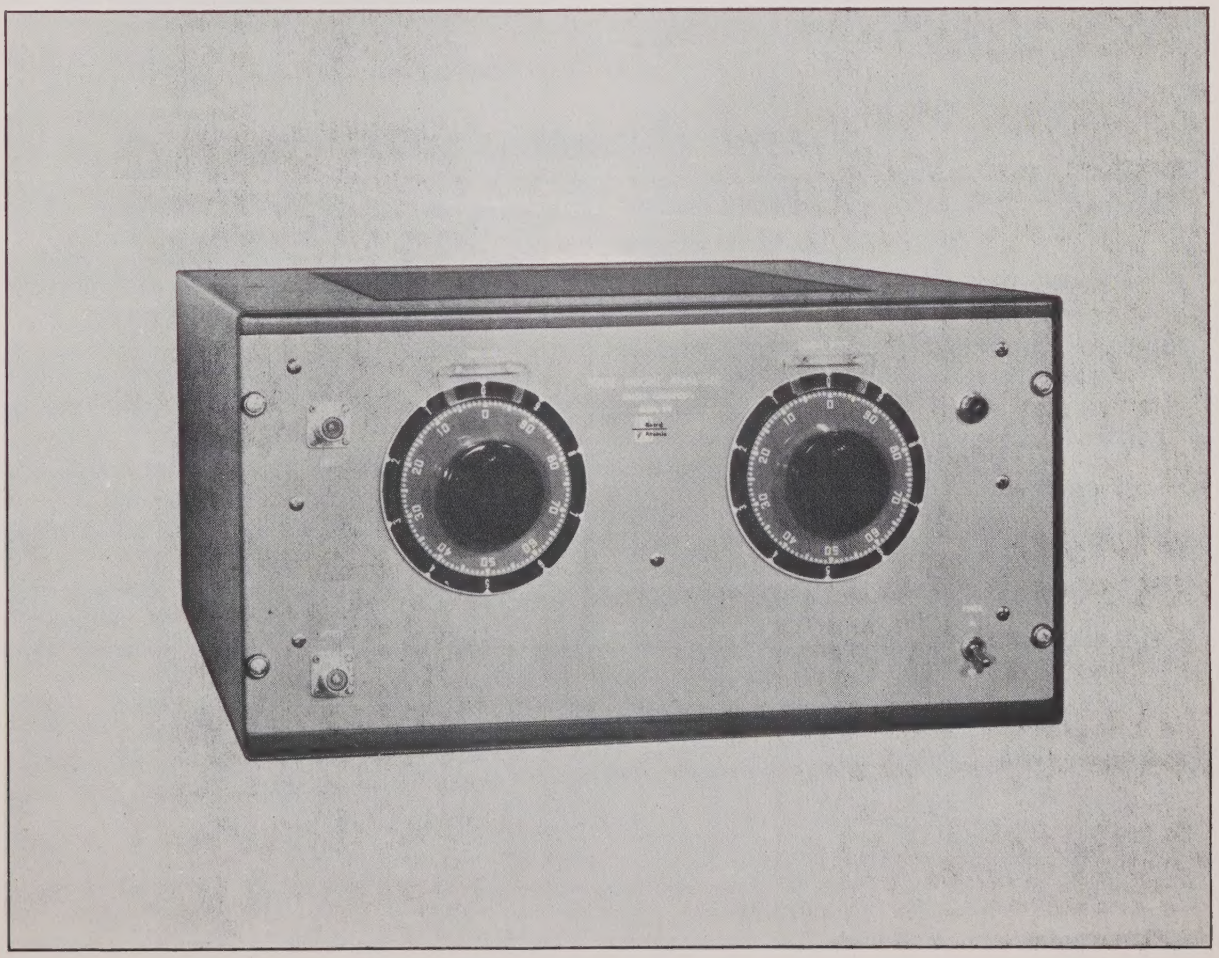


Figure 1-1. Model 510 Single-Channel Pulse Height Analyzer.

3. PRINCIPLES OF OPERATION.

The Model 510 determines two basic items of information: first, whether or not the input pulse has crossed the lower level of the channel, and second, whether or not the pulse has crossed the upper level. The lower-level crossing generates an output signal which is suppressed if the upper level is also crossed. The signals indicating level crossings are generated by Schmitt-type pulse-height discriminators. Discriminators of this type generate a constant-amplitude pulse each time an input pulse exceeds a critical threshold level. The duration of an output pulse, unless the circuit is modified, is equal to the time the input pulse remains above the threshold.

Since the signal generated by a crossing of the upper level appears later in time and terminates earlier than the signal generated from a crossing of the lower level, the information on crossings is stored until the input pulse has terminated. Then an output pulse is generated only if no upper-level crossing has occurred.

The discriminators are fed by a common expander amplifier which is biased-off by the base-line voltage. Therefore it does not generate an output signal until an input pulse of sufficient amplitude crosses the base line. That portion of a pulse which exceeds the base-line voltage is amplified by a constant factor of 10.

Because of this amplification the discriminator thresholds are separated 10 times the width of the channel as referred to the input. In this fashion, stringent stability requirements on the threshold stability of the discriminators are alleviated. If the discriminators were fed directly, a relative drift of only 10 millivolts would change a nominal one-volt window by 1%. However the gain of the expander amplifier reduces the effect of relative drift to a negligible amount.

4. DESCRIPTION OF THE EQUIPMENT.

The Model 510 Pulse Height Analyzer consists of a single major assembly which is housed in a hand-rubbed blond oak cabinet or a blue-grey metal cabinet at the purchaser's option. The panel is 8-3/4 inches high by 19 inches wide and is finished in a blue-grey Hammertone. On it are mounted the base-line and channel-width controls, input and output jacks, and power switch and pilot lamp. The panel and chassis may be removed from the cabinet if desired and mounted in a standard 19-inch relay rack or cabinet.

The principal electrical characteristics of the equipment are summarized in Table I, Reference Data.

TABLE I. REFERENCE DATA

INPUT PULSE SHAPE - Any provided an approximately flat top of at least one microsecond exists. Delay line shaping by a preceding linear amplifier such as the Atomic Model 218 is desirable for best resolution.

RESOLVING TIME (pulse pairs) - 10 microseconds with delay-line shaped one-microsecond pulses.

BASE LINE - Variable 0 to 100 volts.

CHANNEL WIDTH - Variable 0 to 7 volts.

OUTPUT PULSE - Amplitude variable 0 to 15 volts negative.

PRIMARY POWER - 115v 60 cps @ 1.5 amperes.

WEIGHT - 37 lbs.

SIZE (inches) - 20 1/2 wide by 10 1/2 high by 16 1/4 deep.

MATING PLUGS (Input & Output Jacks) - UHF Small Coaxial, Amphenol 83-1SP or equivalent.

TUBE AND INDICATOR LAMP COMPLEMENT

1 - OA2	2 - 6AX5
1 - 6AG7	2 - 12AU7
6 - 6AH6	2 - 12AX7
2 - 6AL5	1 - 5651
2 - 6AQ5	1 - 5687
1 - 6AS7	1 - #47

SECTION II
INSTALLATION

1. GENERAL.

It is recommended that Section I, General Description, be studied carefully for general information before installation. The outline drawing supplied in this section will be useful in planning an installation.

2. UNPACKING AND HANDLING.

The equipment should be carefully unpacked to guard against damage. After removing the cover, take out the excelsior and/or blocking material around the sides of the equipment. When this is done, there is sufficient room around the unit to lift it from the packing case.

Remove the paper wrapping covering the unit, remove padding material inside the cabinet, and carefully clean out all packaging material fragments, dust, or other foreign material.

3. INSPECTION.

After the equipment has been unpacked, inspect it thoroughly for loose parts and connections. Also see that all moving parts, switches, and controls move and operate properly without binding or rubbing.

The electron tubes and indicator lamps should be inspected to see that none were broken during shipment. Even though they may be found in proper mechanical condition, it is advisable to remove the tubes and lamps and check the filaments for continuity with an ohmmeter before placing them in the equipment. Make sure that the incandescent lamp used as an indicator is firmly seated in its socket.

Each equipment is shipped with a full complement of tubes mounted in their sockets. All tubes are equipped with locking devices to keep them from working loose under vibration or shock. The miniature-type tubes are retained in their sockets by means of a conical spring which fits over the bulb. The rectifier tube has a special locking device which keeps it from working loose under vibration or shock.

4. LOCATION OF EQUIPMENT.

The equipment is self-contained. It may either be used in its own cabinet placed on a bench or table, or it may be removed and mounted in a relay rack. No side access is required. Therefore it can be placed next to a wall or between other units. There should be a back clearance behind the equipment sufficient to make connections and provide adequate ventilation.

5. ENERGIZING THE EQUIPMENT.

If the installing personnel wish to operate the equipment, reference should be made to Section III, Operation, for operating procedures.

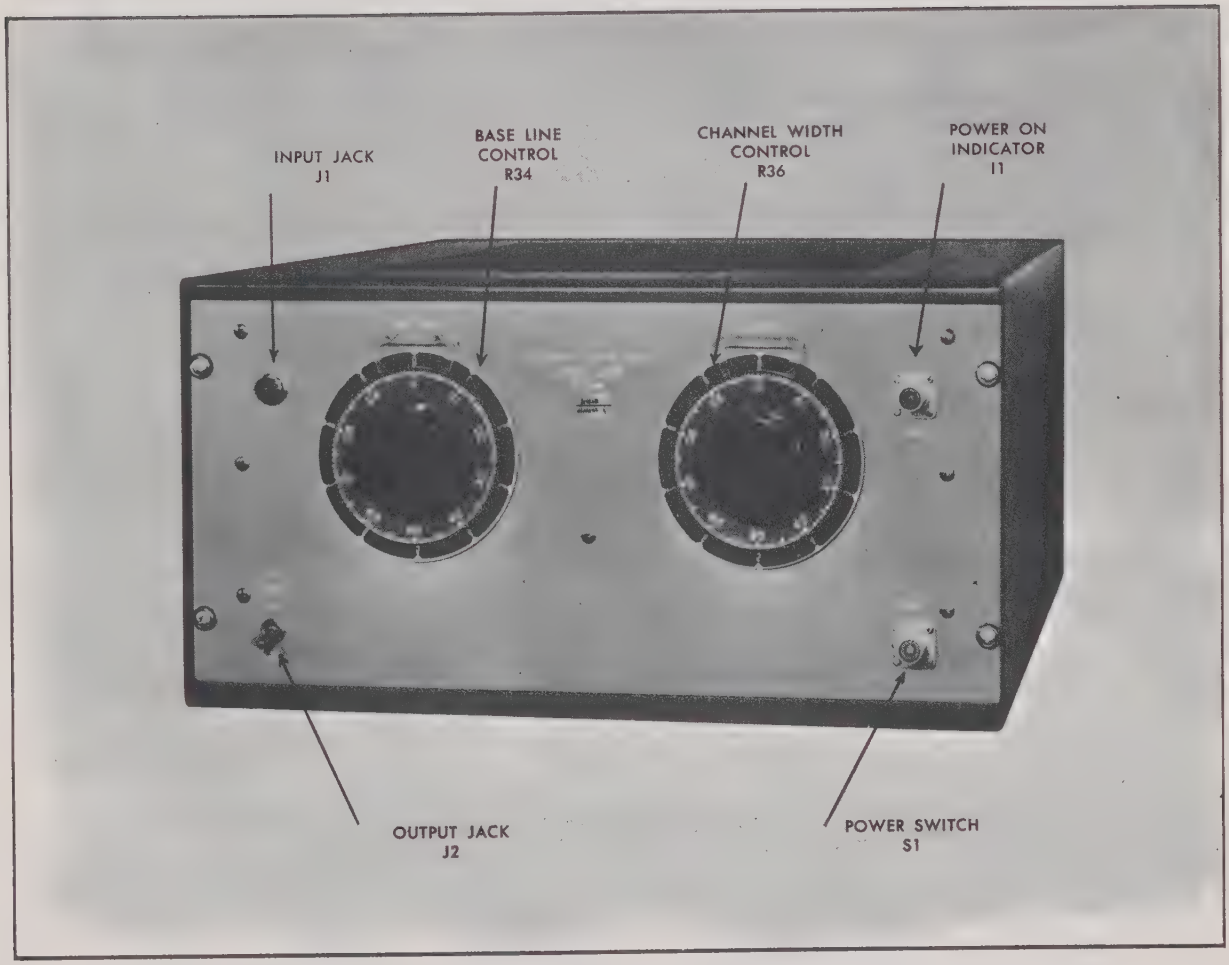


Figure 3-1. Model 510: Location of Operating Controls.

SECTION III
OPERATION

1. GENERAL.

Before placing the equipment in operation, the operator should study carefully the instructions given in this section for a thorough understanding of the function of the controls and limitations of the equipment.

Control names that appear in the text are copied exactly from front-panel markings and are capitalized thus: BASE-LINE Control, OUTPUT Jack, etc. Controls that are not named on the equipment are printed thus: Power On Indicator.

2. OPERATING CONTROLS.

All operating controls for the Model 510 are shown in figure 3-1. None of the internal controls should be touched by the operator. These controls are for the use of maintenance personnel only.

The BASE-LINE Control R34 is used to establish the lower level of pulse acceptance. It is variable from 0 to 100 volts in 10 complete revolutions (1000 dial divisions). Each division on the dial is therefore 0.1 volt.

The CHANNEL WIDTH Control determines the width of the acceptance channel or window. It establishes the upper level of pulse acceptance in terms of volts above the base line. As the BASE-LINE Control is varied, the upper-level and lower-level acceptance limits vary ambiguous simultaneously, thereby maintaining a constant separation as determined by the setting of the CHANNEL WIDTH Control. The useful range of this control is 0 to 7 volts in seven complete revolutions (700 dial divisions). Each division on the dial represents 0.01 volts.

NOTE

Mechanically the CHANNEL WIDTH Control is variable through 10 complete revolutions. Because of expander-amplifier saturation, the last three (701 to 1000 dial divisions) are not to be used except when the instrument is used for integral-bias measurements. This application is discussed later in the section.

The functions of the INPUT and OUTPUT Jacks, POWER Switch, and Power On Indicator are self-evident. Mating plugs for the two jacks are listed in Table I, Reference Data.

3. OPERATING PROCEDURE.

a AUXILIARY EQUIPMENT.

The Model 510 is normally used in conjunction with a radiation detector, linear amplifier, and a scaler as shown in figure 3-2. The linear amplifier following the radiation detector should be capable of producing an undistorted output pulse of at least 100 volts amplitude.

Figure 3-2. Block Diagram of Model 510 and Auxiliary Equipment.

b. OPERATION.

To energize the equipment, check that the power plug is connected to a 115 volt 60 cps source of primary power. Then turn the POWER Switch ON. The Power On Indicator Lamp will light. Approximately 30 seconds warm-up time should be observed before use to make certain all electron tubes have reached proper operating temperature. Set the BASE-LINE Control at the lower-level voltage of pulses to be counted and set the CHANNEL WIDTH Control at the window width desired. The equipment is now ready for use.

c. OPERATING NOTES.

(1) Determination of Effective Channel Width.

The effective channel width at any given setting of the CHANNEL WIDTH Control R36 may be determined in the following fashion for a repetitive input pulse of given shape and amplitude

NOTE

Increase the setting of the BASE-LINE Control R34 slowly from a low value to the point at which an output pulse first appears. Note the BASE-LINE Control reading.

Then further increase the setting of the BASE-LINE Control until the output pulse just ceases. The effective channel width is the difference in volts between the two critical settings of the BASE-LINE Control.

This procedure causes the pulse to pass through the channel boundaries from above. At the first setting the pulse top is just below the upper lead of acceptance. At the second setting is just below the lower level of pulse acceptance.

On the other hand, the CHANNEL WIDTH Control may be set by means of a test pulse generator to a specific effective width in the following way.

First set the BASE-LINE Control at the desired upper acceptance level and, with the CHANNEL WIDTH Control at some value larger than the desired channel width, adjust the test pulse amplitude from a low value to a point at which an output signal first appears. Then reduce the BASE-LINE Control Setting by an amount equal to the desired channel width. The BASE-LINE Control is now set at the lower acceptance level. Next reduce the setting of the CHANNEL WIDTH Control until output pulses just cease. At this setting is the desired effective channel width.

(2) Synchronization with Chart-Drive Mechanism.

Both the BASE-LINE and CHANNEL WIDTH Potentiometers are each fitted with a short length of cable and a plug which mates with an appropriate receptacle. Similar units equipped with the same type plugs and geared to chart-drive or other mechanisms may be substituted electrically for one or both panel-mounted potentiometers. Voltage divider strings of fixed resistors and tap switches may also be used to achieve discrete steps in base-line voltage and/or channel width. In such fashion automatic synchronization with recorder systems may be obtained.

(3) Integral-Bias Measurements.

The Model 510 can be used for integral-bias (cumulative-distribution) measurements merely by setting the CHANNEL-WIDTH Control R36 at 10 volts. Because of saturation of the expander amplifier at a point somewhat above 7 volts, a pulse from the expander amplifier cannot trigger the upper-level discriminator. Consequently, an output pulse occurs for each input pulse having an amplitude greater than the setting of the BASE-LINE Control.

4. OPERATING PRECAUTIONS.

Since the expander amplifier observes only a small portion of the input pulse, severe requirements are placed on the amplifier so that it will perform satisfactorily its intended functions. It must have a gain of ten and the bandwidth must be very large. An ideal amplifier of this type would have an infinite bandwidth. In addition the amplifier must maintain a high degree of linearity and not produce spurious responses when severely overloaded.

The expander amplifier used in the Model 510 satisfies these requirements to a degree which is commensurate with the over-all accuracy and stability of the unit. However it should be remembered that when the amplifier is called upon to amplify the peak of a large narrow pulse, the finite amplifier bandwidth causes deterioration of the desired linear relationship between input and output. For this reason the pulse supplied to a Model 510 should not be any shorter than is absolutely necessary. Better performance will be obtained by tolerating a lower counting rate to allow the use of a longer input pulse. As the amplifier is called on to amplify shorter and shorter pulses, the gain will fall because of the high-frequency response limitation.

The effect, as noticed in the over-all performance of the analyzer, is an effective increase in the channel width, read on the BASE-LINE Control, as the input pulse is made shorter and shorter. An apparent increase in channel width will also be noted when increasing the amplitude of a short pulse having a fixed duration. These effects must be taken into account in the use of the analyzer. The window width remains essentially constant for pulses above a certain minimum rise time and duration.

SECTION IV
THEORY OF OPERATION

1. OVER-ALL CIRCUIT FUNCTION.

The over-all function of a Model 510 Single-Channel Pulse Height Analyzer is shown on the functional block diagram, figure 4-1. That portion of an input pulse whose amplitude exceeds the setting of the BASE-LINE Control R34 is amplified 10 times by the expander amplifier. The output of the expander amplifier in turn feeds two discriminators whose thresholds are separated 10 times the desired channel width. The separation is determined by the setting of the CHANNEL WIDTH Control R36.

Any signal which exceeds the base-line voltage will trigger the lower-level discriminator. The discriminator generates a pulse which is applied to one input of a difference amplifier whose output is proportional to the potential difference between its inputs. However if the upper-level discriminator is also triggered, an identical pulse is applied to the second input. Under this condition no output results since the net potential difference between the two inputs is zero. Since there is also no output if the amplitude of the signal is insufficient to overcome the base-line voltage, an output signal is generated only if the top of a signal pulse falls within the boundaries of the channel; i. e. , whenever the lower level but not the upper level discriminator is triggered.

NOTE

In the following paragraphs, the operating principles of the various circuits are discussed in detail. As far as possible, the presentation is in the order of signal flow through the equipment. Unless otherwise stated references are to the schematic diagrams at the end of Section VI.

2. EXPANDER AMPLIFIER.

The gain characteristic of an ideal amplifier is shown in figure 4-2. Not only must the expander threshold be adjustable over the desired spectrum range, but at any setting it must also be as stable as possible. At low thresholds, many pulses will be sufficiently large to saturate the amplifier. It must, therefore, overload gracefully and not cause overshoots or other disturbances of the base line.

The gain must remain as constant as possible, independent of threshold, time, pulse-frequency content, pulse shape, and pulse size except for overload pulses. The expander amplifier used meets these ideal specifications within an acceptable tolerance.

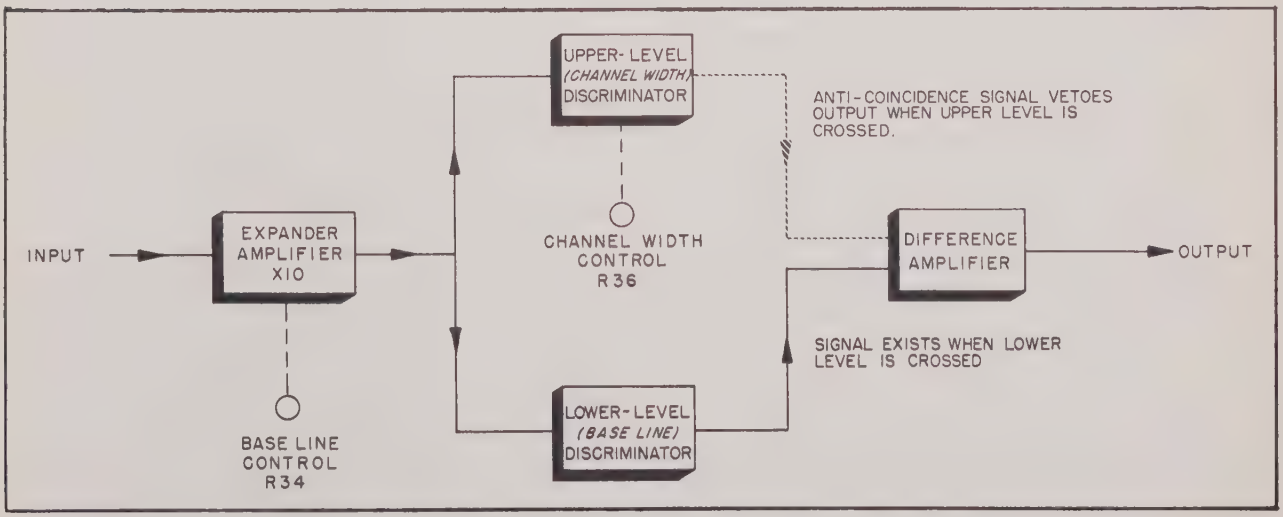


Figure 4-1. Model 510: Block Diagram.

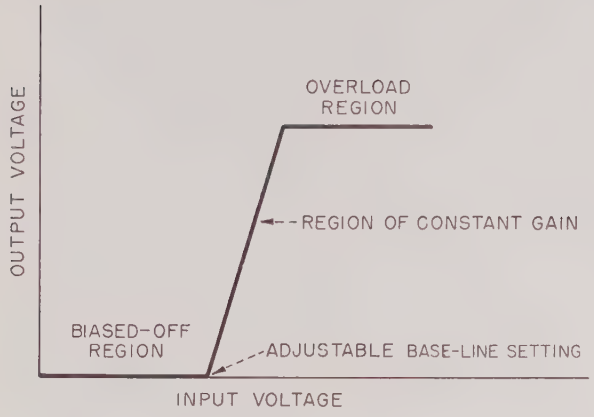


Figure 4-2. Gain Characteristics of Ideal Expander Amplifier.

The expander amplifier consists of a cathode-coupled amplifier comprising V1 and V2 with V3 which in turn drives a series-connected output stage comprising V4 and V5. V1 is biased beyond cutoff by the base-line voltage determined by R34. The effects of changing tubes, varying voltages, and contact potential drift are minimized by operating V1 and V2, tubes of the same type, in a difference amplifier circuit so that their respective drifts balance. The output signal depends only upon the potential difference between the grids of V1 and V2. Type 6AH6 tubes are used for their high-gain bandwidth product.

When the input signal amplitude reaches the cutoff potential of V1, the tube starts to conduct. Because of the logarithmic nature, near cutoff, of the transfer characteristic, the beginning of the output pulse in a conventional amplifier of this type is rather indeterminate. Furthermore, the initial rise of the output pulse is slow because the transconductance of V1 is low when conduction is initiated, increasing rapidly as the plate current increases. Crystal diode CR1 has been added between the plates of V1 and V2 to make the breakaway, or start of the pulse, more abrupt as explained in the following paragraph.

Tube V2 normally conducts fairly heavily; consequently, a quiescent voltage drop exists across plate load resistance R7. The crystal diode is so connected that current through the diode holds the plate voltage of V1 at a level almost equal to that of V2 even though V1 is not conducting. When the input signal drives V1 to conduction, the initial conduction of this tube in the low transconductance region occurs before an output signal appears at the plate. As soon as plate current in V1 exceeds the current in V2 (no conduction in CR1), an output signal appears. The beginning of this output pulse has a fast rise since V1 is now operating in a high transconductance region.

Because capacitive coupling exists between the grid and cathode of V1, some grid signal will be coupled to the cathode, even when the grid is biased far beyond cutoff. The amount of signal capacitively coupled is a function of the rate of rise of the input pulse. For large short pulses this coupling may cause an appreciable signal at the common cathode connection of V1 and V2. This cathode signal unless eliminated appears amplified at the plate of V2 and, by means of coupling through diode CR1, at the plate of V1.

Constant-current tube V3 and associated circuit elements have been added to eliminate the effect of this capacitive coupling. To the control grid of V3, a type 6AQ5, is fed a cancellation pulse derived from the input signal through quasi-differentiating circuit R2 C2. The proper cancellation pulse, obtained at the correct setting of C2, causes the plate current of V2 to be momentarily increased so that the displacement current from the grid of V1 to the cathode is immediately conducted to ground. As a result, no spurious voltage pulse appears across the cathode-to-ground capacitance.

The level of input signal at which tubes V1 and V2 begin to form an output pulse is determined by the relative voltages on the grids of these tubes. The bias (base line) voltage for the grid of V1 is obtained from potentiometer R34 through R4. Potentiometer R31, a Base-Line Zero-Set Control, has a range of approximately plus or minus two volts from the zero dial position (maximum voltage at the arm) of R34. Adjustment of R31 permits compensation for changes in the characteristics of tubes V1 and V2, and also for changes which occur when tubes are replaced.

When an input pulse of sufficient magnitude is applied to the grid of V1, a negative signal appears at the plate and is coupled to the grid of V5. The quiescent grid bias of V5 is held close to zero by grid current through R12 from the +300 volt supply; therefore, V5 conducts heavily with a quiescent plate potential of approximately 60 volts. When the negative signal from V1 is applied to the grid of V5, the plate of V5 immediately starts to rise; this positive signal is coupled to the grids of V4 through C13. Since V4 is a cathode follower, rising grid voltage causes an almost equal rise in cathode voltage. The rising cathode voltage of V4 increases the effective plate-supply voltage of V5 by an amount almost equal to the original increase in its plate voltage. Thus a very high incremental load resistance is presented to V5, while still allowing the tube to operate with high transconductance thereby high gain, short rise time, and a large output voltage swing is obtained without resorting to a high plate-supply voltage. Because of the number of tubes in this feedback amplifier, it is prone to oscillate at a high frequency. Instability is prevented by deliberately adding shunt capacitance from the plate of V5 to ground - namely, the heater-cathode capacitance of V6, and the effect of C12 between grid and cathode of V4.

One section of dual diode V6 holds the grid bias of V4 at a minimum value of 150 volts. Signals drive the grid of V4 above this level, but when a signal is removed, the grid is held by the diode at 150 volts, ensuring thereby a minimum 150-volt plate-supply volt-

age for V5. The other section of V6 limits the plate voltage of V5 when it reaches 150 volts, clipping the output pulse so that the discriminators following will not be overloaded. The 150-volt bias for both sections of V6 is obtained from voltage-regulator tube V7 through the filter comprising R18 and C14.

The amplifier output signal is taken from the cathodes of V4 at a low impedance level. A portion of the output is fed back to the grid of V2, the amount being determined primarily by the frequency-compensated voltage divider R10, R11, C9, and C10. Feedback at low frequencies is determined by R10 and R11, and at high frequencies by C9 and C10. The feedback and input signals are subtracted in difference amplifier V1 - V2.

The gain without feedback of the expander amplifier is approximately 750, so that an overall gain of ten at low frequencies is obtained by making R11 equal to one tenth of R10 plus R11. C9 is adjusted to maintain constant the amplifier gain to the highest possible frequency.

3. DISCRIMINATORS.

In order to more easily follow the action of the discriminators and following circuits, idealized waveforms and time relationships are shown in figure 4-3. The output pulse from the expander is shown sufficiently short that the channel-width discriminator remains triggered after restoration of the base-line discriminator. This can occur because the channel-width discriminator output pulse is made 1 μs minimum.

The discriminators, or pulse amplitude selectors, used in this unit are a conventional type known as the Schmitt trigger circuit. The lower-level or base-line discriminator, V11 and V12, is completely conventional. The triggering level is determined by the voltage across potentiometer R36 and the voltage divider consisting of R40, R41, R43, and R44. It is desired that triggering of the base-line discriminator occur whenever there is any appreciable output from the expander amplifier, but to avoid difficulties arising from discriminator hysteresis, the triggering level is adjusted by R44 to approximately five volts. When this five-volt triggering level is divided by the amplifier gain of ten, thus referring it back to the input, pulses below approximately one-half volt in amplitude will not operate the discriminator circuit. The width of the output pulse from the base-line discriminator is equal to the length of time the pulse from the expander amplifier remains above the triggering level.

When the discriminator is triggered, a positive pulse of approximately 20 volts appears at the plate of V12. This positive pulse is coupled to cathode follower V13, producing a pulse at the left-hand cathode whose amplitude is approximately equal to that appearing at the plate of V12, and whose duration is equal to the length of time the expander amplifier output pulse remains above the triggering level.

The upper-level or channel-width discriminator, consisting of tubes V8, V9, and V10, is a modified Schmitt trigger circuit. Since this discriminator may be biased far beyond cutoff and receive large pulses which have a relatively short rise time, V9 has been added to perform much the same function as V3 in the expander amplifier tube. V9 and a differentiating circuit consisting of R23 and C20 prevent the cathode level of V8 and V10 from rising because of displacement current from the grid of V8. If the cathode level were allowed to rise, there would be an increase in the triggering level of the discriminator. Also, since the output signal is taken from the plate of V10 which normally conducts heavily, a spurious output signal would be produced of the proper polarity to cause false operation of the anti-coincidence circuits. The base-line discriminator need not be so compensated because the grid of V11 moves only five volts before conduction is initiated.

A major feature of the upper-level as compared with the lower-level discriminator is the addition of circuitry to obtain a minimum pulse duration of one microsecond. The duration of the output pulse from a conventional Schmitt circuit is very nearly equal to the length of time the input pulse remains above the triggering level. Consequently when the top of a short, high amplitude pulse is being measured, the discriminator may be triggered for only a small fraction of a microsecond. For the anti-coincidence circuit to operate properly, capacitors C30 and C31 must be discharged by an amount equal to the full amplitude of the discriminator pulse. The discharging process requires a minimum pulse duration of about a microsecond.

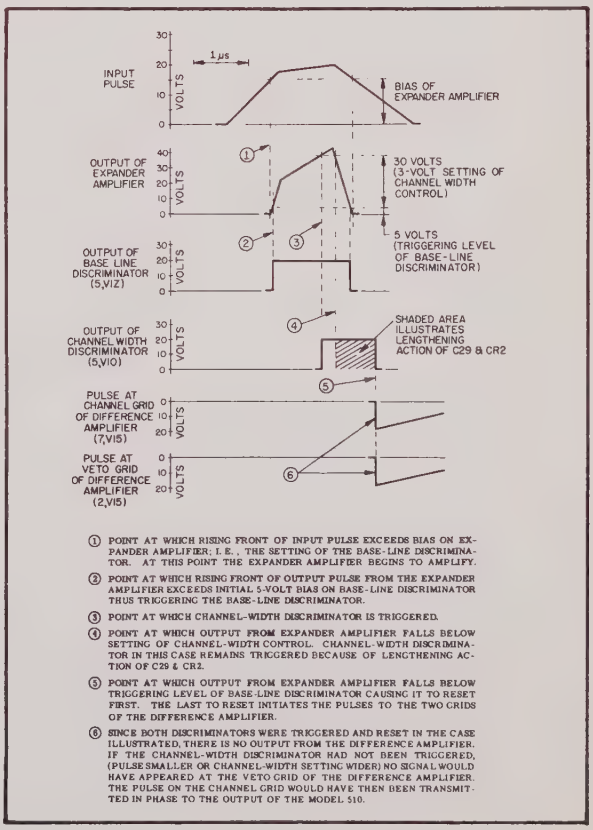

INPUT PULSE
1 μs
VOLTS
BIAS OF EXPANDER AMPLIFIER
OUTPUT OF EXPANDER AMPLIFIER
30 VOLTS (3-VOLT SETTING OF CHANNEL WIDTH CONTROL)
5 VOLTS (TRIGGERING LEVEL OF BASE-LINE DISCRIMINATOR)
OUTPUT OF BASE LINE DISCRIMINATOR (5,V12)
SHADED AREA ILLUSTRATES LENGTHENING ACTION OF C29 & CR2
OUTPUT OF CHANNEL WIDTH DISCRIMINATOR (5,V10)
PULSE AT CHANNEL GRID OF DIFFERENCE AMPLIFIER (7,V15)
PULSE AT VETO GRID OF DIFFERENCE AMPLIFIER (2,V15)
① POINT AT WHICH RISING FRONT OF INPUT PULSE EXCEEDS BIAS ON EXPANDER AMPLIFIER; I.E., THE SETTING OF THE BASE-LINE DISCRIMINATOR. AT THIS POINT THE EXPANDER AMPLIFIER BEGINS TO AMPLIFY.
② POINT AT WHICH RISING FRONT OF OUTPUT PULSE FROM THE EXPANDER AMPLIFIER EXCEEDS INITIAL 5-VOLT BIAS ON BASE-LINE DISCRIMINATOR THUS TRIGGERING THE BASE-LINE DISCRIMINATOR.
③ POINT AT WHICH CHANNEL-WIDTH DISCRIMINATOR IS TRIGGERED.
④ POINT AT WHICH OUTPUT FROM EXPANDER AMPLIFIER FALLS BELOW SETTING OF CHANNEL-WIDTH CONTROL. CHANNEL-WIDTH DISCRIMINATOR IN THIS CASE REMAINS TRIGGERED BECAUSE OF LENGTHENING ACTION OF C29 & CR2.
⑤ POINT AT WHICH OUTPUT FROM EXPANDER AMPLIFIER FALLS BELOW TRIGGERING LEVEL OF BASE-LINE DISCRIMINATOR CAUSING IT TO RESET FIRST. THE LAST TO RESET INITIATES THE PULSES TO THE TWO GRIDS OF THE DIFFERENCE AMPLIFIER.
⑥ SINCE BOTH DISCRIMINATORS WERE TRIGGERED AND RESET IN THE CASE ILLUSTRATED, THERE IS NO OUTPUT FROM THE DIFFERENCE AMPLIFIER. IF THE CHANNEL-WIDTH DISCRIMINATOR HAD NOT BEEN TRIGGERED, (PULSE SMALLER OR CHANNEL-WIDTH SETTING WIDER) NO SIGNAL WOULD HAVE APPEARED AT THE VETO GRID OF THE DIFFERENCE AMPLIFIER. THE PULSE ON THE CHANNEL GRID WOULD HAVE THEN BEEN TRANSMITTED IN PHASE TO THE OUTPUT OF THE MODEL 510.

Figure 4-3. Model 510: Time Diagram

When the discriminator is triggered, a positive pulse appears at the plate of V10 which is coupled to cathode follower V13, producing a positive pulse at the right-hand cathode. This pulse is coupled to the anti-coincidence circuit, and, through CR2 and C29, to the cathode circuit of V8 and V10, thereby raising this cathode potential above its normal level by an amount nearly equal to the pulse amplitude. Hence V10 cannot return to the conducting condition even if the input pulse is removed from the grid of V8. The discriminator cannot restore until C29 discharges, allowing the cathodes of V8 and V10 to return to their normal level. The duration of the output pulse, approximately one microsecond, is determined by the length of time required to discharge C29. When the discriminator restores, C29 recharges through R51. If the input pulse remains above the triggering level of the discriminator longer than one microsecond, C29 is discharged and has no effect; the output pulse duration is then determined only by the length of time the input pulse holds V8 conducting.

The base-line discriminator need not incorporate this pulse-lengthening feature because of the low bias (five volts) and because capacitor C27 over-compensates resistance divider R41, R43, R44. The circuit behaves therefore as a univibrator. For sufficiently short input pulses, the output pulse duration is constant and independent of input pulse duration.

The effective channel width of the analyzer is equal to the voltage difference in the triggering levels of the two discriminator circuits divided by the gain of the expander amplifier. CHANNEL WIDTH Control R36 allows the difference in these triggering levels to be set at any value between zero and 100 volts, a possible range of channel width of zero to nearly ten volts when referred to the input. However saturation of the expander amplifier normally limits the maximum usable channel width to about seven volts. This makes possible the use of the analyzer for cumulative-distribution (integral-bias) measurements. Simply increase the CHANNEL WIDTH Control to ten volts; then because of saturation effects the expander-amplifier output pulse can never trigger the upper-level discriminator. Consequently, an analyzer output pulse occurs for every input pulse having an amplitude greater than the setting of the BASE-LINE Control R34.

4. ANTI-COINCIDENCE CIRCUIT.

An output pulse from the Model 510 appears only when the top of an input pulse lies between the two discriminator levels. No output pulse should appear if both discriminators trigger and, of course, no output pulse will appear if neither discriminator triggers. The anti-coincidence section of the Model 510 is arranged to cancel the pulse from the base-line discriminator if a pulse appears from the channel-width discriminator.

A pulse from the base-line discriminator appearing at the left-hand cathode of V13 is coupled to the network consisting of C31, CR5, R52, and C32. Since the pulse coupled to C31 is positive, diode CR5 conducts and forms a low-impedance path to ground to discharge capacitor C31. C31 discharges during the pulse by the amount of the pulse amplitude. When the pulse is removed and the left-hand cathode of V13 returns to its previous level, diode CR5 opens and C31 charges through the higher resistance path offered by R52. As a result a negative exponential pulse is applied to the grid of V15. In the absence of a pulse from the channel-width discriminator, a negative output pulse appears at the plate of V15A; thus identifying an input pulse whose amplitude lies within the limits of the channel.

When the pulse top exceeds the bias level of the channel-width discriminator, a positive pulse is produced at the right-hand cathode of V13 which is coupled through the upper half of diode V14 to the network consisting of C30, CR4, and C32. C30 discharges through the low-impedance path of CR4 and C32 by the amount of the pulse amplitude. Diode CR3 isolates from the grid of V15A the positive pulse produced by the discharge current of C30 through the forward resistance of CR4, thereby preventing spurious output signals. Since the duration of the pulse from the channel-width discriminator is less than the duration of the pulse from the base-line discriminator, some means must be provided to lengthen the pulse from the channel-width discriminator until the base-line discriminator is restored. When the channel-width discriminator returns to its original condition after being triggered, the upper half of V14, now nonconducting, allows the existing charge in C30 to remain, thereby storing the information that the upper level has been crossed. This charge remains until the base-line discriminator is restored and the left-hand cathode of V13 drops to its normal level, causing the lower half of V14 to conduct and offer a low-resistance path to ground from the left side of C30. A negative exponential pulse will then be coupled through diode CR3 to the grid of V15A. This pulse has a decay time constant equal to that of the pulse applied to the grid of V15B. If both grids of V15, a cathode-coupled difference amplifier, are actuated by identical signals, no output pulse will be generated. Thus the anti-coincidence circuit insures that no output pulse will be produced if both discriminators are triggered. Furthermore, anti-coincidence does not take place until the base-line discriminator returns to its normal condition, thus ensuring that the channel-width discriminator has had time to be triggered by the input pulse. The amplitude of the output pulse is controlled by adjusting the value of the plate-load resistor R56 of V15A. As the output pulse is attenuated by reducing the value of R56, the first effect, before the amplitude of the main output pulse is reduced, is to reduce any noise pulses which may result from partial anti-coincidence. R56 thus has a secondary effect of controlling the signal-to-noise ratio of the output circuit. This noise reduction is achieved by the break-away action of diode CR6 which operates in a manner analogous to that of CR1 in the expander amplifier.

Note that the test for anti-coincidence between the two discriminators does not occur until the base-line discriminator restores, hence not until the input pulse has again fallen below the restoring level of the base-line discriminator. The analyzer output pulse thus appears significantly later in time than the input pulse and cannot be used for time-coincidence measurements.

5. POWER SUPPLY.

The power supply used is a conventional rectifier -filter-regulator type. Excellent long-time stability is achieved through the use of wire-wound resistors in the voltage-sampling divider and the stable type 5651 reference tube V21 operated solely as a reference-voltage source at constant current. Excellent short-time stability and relatively low output ripple voltage are achieved by using high gain around the regulator loop. A Sola constant-voltage transformer regulates the heater voltage supplied to certain stages of the analyzer which otherwise might drift with changes in heater temperature and thereby cause changes in the calibration of the unit.

Transformer T1 supplies alternating voltage to the plates of rectifier tubes V16 and V17. Resistors R59, R60, R61, and R62 in series with the rectifier plates are a precaution against local parasitic oscillations. The rectifier output is filtered by R79, L1, C36, and C37. L1 in the negative leg of the filter reduces the probability of breakdown between the winding and core.

A sample of the regulated output voltage is obtained from the voltage divider consisting of R69, R70, and R71 and is connected to the grid of V20A. The sampled voltage is compared in difference amplifier V20 with the reference voltage from V21. Any deviation between the sampled voltage and the reference voltage appears, amplified, as a difference in plate voltage between the two sections of V20. V19B is a cathode follower which effectively transfers the voltage at the plate of V20A to the cathode of V19A. At the same time the grid of V19A is connected to the plate of V20B. The grid-cathode voltage of V19A is thus essentially the difference voltage between the grids of V20, amplified. In this manner a relatively high d-c loop gain is achieved with the circuit completely balanced; heater temperature changes therefore have negligible effect. Alternating ripple voltage and transients are coupled to V19 through C38 and C39, and are amplified by V19A. The output of V19A is fed to dual triode V18 which is used as a conventional series regulator tube.

R63, R64, R65, and R66 are included as a precaution against local parasitic oscillations. Resistor R80 provides a path for the discharge of capacitors C36 and C37. Resistors R76 and R77 form a voltage divider to raise the potential of the heater circuits of several tubes to approximately 90 volts so that no heater-cathode voltage rating is exceeded. The heaters of V16, V17, and V18 are operated at +300 volts for the same reason. R78 and C35 constitute a decoupling network to isolate the heater-circuit transients from the regulated +300-volt bus. In the event of heater -cathode breakdown, R78 acts as a current-limiting resistor.

SECTION V
MAINTENANCE

1. INTRODUCTION.

This section contains information needed for maintenance, repair, and adjustment of the Model 510 Pulse Height Analyzer. The section is divided into three main subsections: Operator's Maintenance, Corrective Maintenance, and Preventive Maintenance.

Operator's Maintenance subsection contains procedures which can be performed, if necessary, by a non-technically trained operator or by personnel unfamiliar with the functioning of the internal circuits.

Corrective Maintenance subsection contains information which permits the technician to locate troubles, to make repairs, and to make adjustments. Voltage- and resistance-measurement tables and illustrations showing component and internal adjustment locations are included to assist the technician. Schematic diagrams follow Section VI.

Preventive Maintenance subsection includes information for inspection, cleaning, lubrication, cleaning and tightening of contacts, and checking of equipment performance. By following the procedures given, the equipment can be kept clean and in peak operating condition.

2. OPERATOR'S MAINTENANCE.

a. GENERAL.

When trouble is experienced, make sure that the correct operating procedure is being used (see Section III, Operation) before assuming that the equipment is faulty. If trouble persists after the checking procedure, the operator should ordinarily refer the trouble to an experienced technician. However under urgent conditions when a maintenance technician may not be available, the following will assist the operator in isolating trouble.

WARNING

Voltages as high as 500 volts exist within the units of this equipment during operation. Contact with such voltage may prove fatal. Do not allow any part of the body to come in contact with any part of any unit inside the cabinet without personally removing the primary power plug from its receptacle.

Probable causes of failure in operation are: primary power failure, fuse failure, and electron tube failure. Most of the components used are resistors and capacitors, which are inherently quite free of trouble. Since these components are of highest quality and are operated well below manufacturers' ratings, the likeliest sources of trouble are the electron tubes, which are inherently shorter-lived and display wider variation in characteristics than the other components.

The operator as well as the technician should familiarize himself with the location of fuses and tubes as well as their spares, so that replacement can be made in an emergency as quickly as possible.

b. FUSE REPLACEMENT.

If none of the tubes or the Power On Indicator light, but primary power is known to be connected, one or both of the fuses located on the rear of the chassis is probably blown. The presence of primary power is easily checked by plugging any 115-volt lamp or a voltmeter into the convenience outlet located on the rear of the chassis below the fuse block.

Replace the defective fuse or fuses with fuses of the same type and rating. Do not use fuses of higher rating.

CAUTION

If a fuse blows again after replacement, do not replace a second time until the fault has been located unless continued operation is more important than possible damage to the equipment. Refer the trouble to an experienced technician.

c. ELECTRON TUBE REPLACEMENT.

If an equipment fails to operate properly, check the possibility of a faulty tube. Bear in mind the sequence of a signal flow through the equipment in order to save time when checking for a faulty tube.

Filaments in glass tubes may be checked by observing whether the tubes light. Tubes with low emission, internal shorts, or cracked bases can be checked most conveniently by replacement with spare tubes that have been previously tested in the equipment. Tubes can also be checked in a tube tester.

To prevent the possibility of replacing a defective tube in the equipment with a tube from spares which is also defective, it is recommended that at least one tested spare be provided for each tube type in the equipment. To do this, it is suggested that during normal operation, each tube be replaced one at a time with a tube spare. If normal operation continues, this tube should be removed, returned to its carton, and reserved for spares usage.

Spare tubes should also be tested in a reliable tube tester and rejected if they do not pass this test. A tube should not be accepted as satisfactory however until it has been tested in the socket in which it is to be used.

If space permits, a complete set of equipment -tested spare tubes should be kept available for the operator. This will expedite servicing since all the tubes in a suspected unit can be replaced at one time.

Where there is insufficient space for a complete set of spares, a minimum number of spares should be kept near the equipment.

WARNING

Most tubes become hot enough during operation to burn the fingers if touched. If a tube must be replaced before it has cooled, use suitable precautions.

3. CORRECTIVE MAINTENANCE.

a. GENERAL.

If substitution of equipment-tested spare tubes and indicator lamps does not clear the trouble, more detailed tests must be made by an experienced technician. Trouble may be localized to a particular circuit or component most effectively by a process of elimination. A great deal of time can be saved by determining what circuit function is involved.

As an aid to quick and effective corrective maintenance, checks for the most common faults are outlined in the following paragraphs. Photographs are included which locate all the replaceable electrical components. In addition there is a sheet of supplementary data giving resistor and capacitor color codes.

Once a faulty component has been located, replacement will not present unusual problems. Components have been arranged for easy access, and replacement procedure in most cases is immediately obvious.

Avoid rough handling of capacitors, and when soldering use as little heat as possible. Bend resistors leads as little as possible to avoid breaking them. Make sure that wire-mounted resistors that dissipate an appreciable amount of heat are so mounted that they do not touch any other component.

It is advisable to grip the wire leads of resistors and capacitors with long-nose pliers between the component and the point of application of the soldering iron. Failure to observe this precaution may result in damaged capacitors and a permanent change in the resistance of resistors.

b. TEST EQUIPMENT.

It is assumed that actual operation of various types of test equipment will be covered by instructions supplied by their manufacturers.

(1) Tube Tester.

Tubes should be tested in a reliable tube tester and rejected if they do not pass this test. A tube should not be accepted as satisfactory however until it has also been tested in the socket in which it is to be used. This is true of all tubes except rectifiers, which may be accepted if they pass emission and gas tests

(2) Volt-Ohm-Milliammeter.

Voltage readings in this section were taken with a Simpson Model 260 having an internal resistance of 20,000 ohms per volt dc and 1000 ohms per volt ac. This or an equivalent instrument is necessary as well for adjustment of voltages within the Model 510.

If an instrument having a different internal resistance is used, most voltage readings will vary from those shown by an amount depending upon the internal resistance of the instrument used. Resistance readings will not be affected by the characteristics of the instrument used.

Ordinarily voltage and resistance scales should be so chosen that the meter will read as near midscale as possible. At times somewhat greater accuracy in reading voltages can be obtained by using the highest scale practicable in order to take advantage of the higher internal resistance of the instrument on the high-voltage ranges.

(3) Oscilloscope.

For adjustments to be described, an oscilloscope is required which has a wide-band high-gain vertical amplifier, triggered sweeps, and a low-capacity input probe. Instruments having a more restricted response will not reproduce these wave forms exactly, and distortion is to be expected. The amplitude of pulses of short duration will be greatly reduced, and steep wave fronts will appear to have abnormal slope.

The Tektronix Model 513-D Oscilloscope, or an equivalent, is an oscilloscope well suited for testing and adjusting the Model 510. Distortion of the pulse shape is extremely small when properly used. The sweep can be initiated by the pulse to be observed, and the delay feature permits the entire pulse to be viewed. This instrument is supplied with an R-C compensated probe having an input resistance of 10 megohms paralleled by a capacity of 14 mmf.

The Tektronix Model 514-AD is also usable. Since however the accelerating potential on the cathode-ray tube is quite low compared to the Model 513-D, the trace intensity at high writing rates suffers by comparison.

(4) Pulse Generator.

In general the scintillation probe or any other device used as a radiation detector can be used as a source of test pulses for signal-tracing purposes. There is no known commercially manufactured instrument available for generating suitable test pulses. However a suitable generator - the Model 100 - is described by Elmore and Sands in their ELECTRONICS, First Edition, 1949, McGraw-Hill Book Company, Inc., beginning on page 322. Such an instrument is necessary for certain adjustments described later.

Pulses should have a short rise time of approximately 0.1 microsecond followed by a flat top of about 1 or 2 microseconds. Amplitude of the pulses should be readily varied, and it is desirable that the

amplitude be known to a high degree of accuracy at least at one level to calibrate the BASE-LINE Control. The low-frequency ripple and noise modulation of the pulses should be low in order that the discriminator triggering levels be well defined.

In using a pulse generator for signal tracing, adjustment, and/or calibration purposes, it should be connected to the Model 510 through whatever amplifier is to be used in making actual measurements of pulse amplitudes.

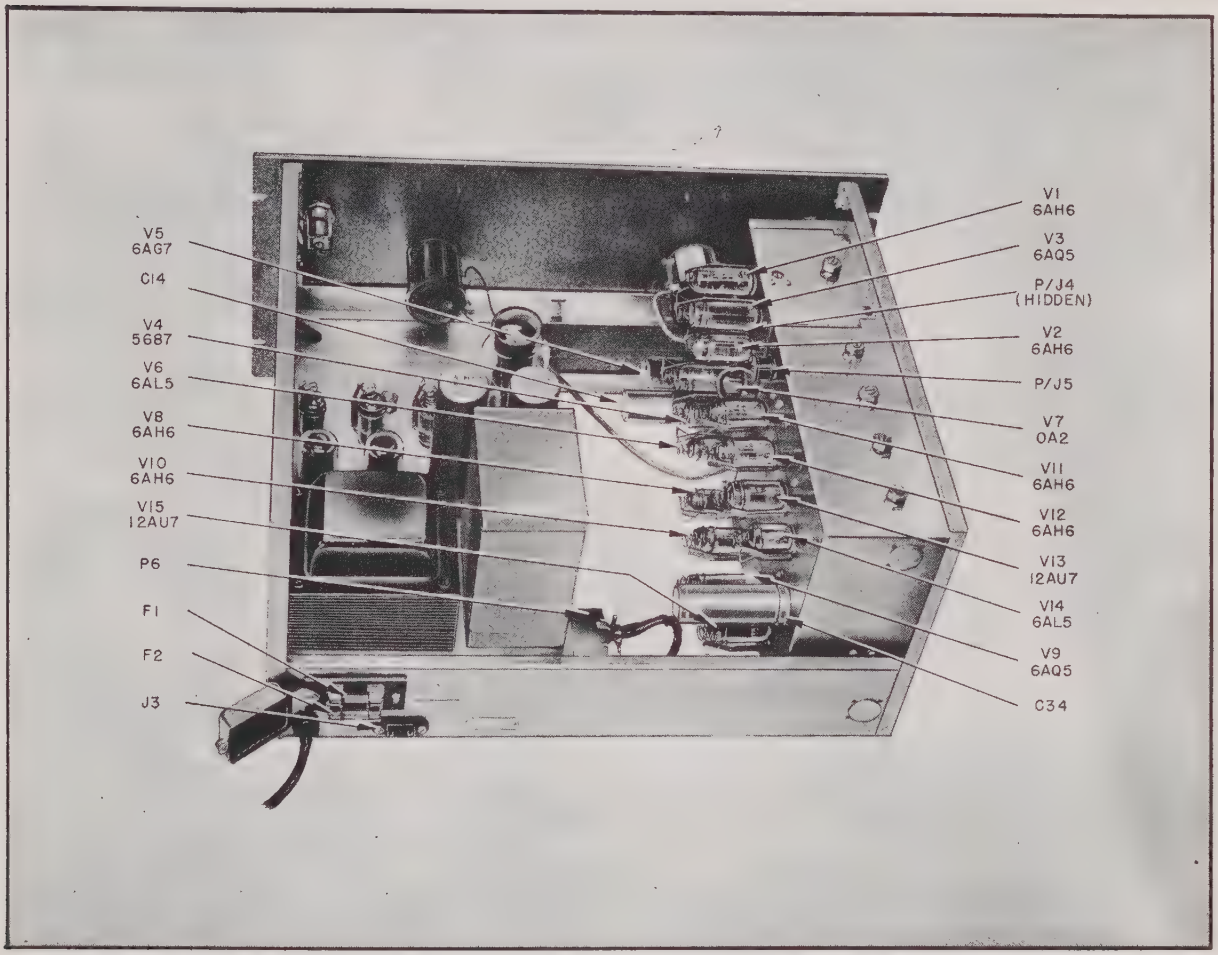


Figure 5-1. Model 510, Rear and Top Oblique View: Location of Components.

c. SIGNAL TRACING.

Checking signal flow step-by-step from input to output is usually the best procedure to locate a fault. Once a malfunctioning circuit group has been isolated, the use of Table II, Voltage and Resistance Measurements, will assist in locating faulty resistors, shorted capacitors, etc.

d. VOLTAGE AND RESISTANCE MEASUREMENTS.

Once a fault has been isolated to a particular circuit group, checking of voltages and resistance with the value given in Table II, Voltage and Resistance Measurements, will locate most of the faults caused by defective resistors or shorts in capacitors or wiring.

The values of resistance given represent an average of several production equipments. Small variations may be expected and should not be taken as definite indications of trouble. Large variations however should be investigated since they may indicate actual or impending failure.

e. TROUBLE SHOOTING NOTES.

(1) Fuse Failures.

Repeated fuse failure at the same position should be investigated. Check for damaged cabling between and within units. An a-c ammeter (suitable fused), substituted for a failing fuse, will often help to identify the trouble.

A failing fuse in a line supplying a transformer may be overloaded due to either a faulty transformer or an overload on the transformer. Before condemning the transformer, remove all but the primary leads and apply power to the transformer. If a wattmeter is available, it will then be a simple matter to determine whether it is overheating (not over an hour). If the transformer is not wasting power, it should not be condemned. Look instead for the cause of its overload.

NOTE

A transformer will usually waste power only if some of its turns are shorted. Sometimes this can be determined by measuring its d-c resistance, but often the number of shorted turns will be less than the allowable tolerance. Therefore the d-c resistance measurement is not always a reliable check.

(2) Power Supply Troubles.

A faulty power supply is usually indicated by fuse failure; high, low, or zero output voltage; or in the case of plate and bias supplies, too much hum (ripple voltage), indicating poor filtering.

If a fuse fails repeatedly or the supply shows other signs of overload, remove the rectifier tube or tubes involved. If the fuse no longer fails, the trouble is probably either a defective rectifier tube or an overload on the supply. Before trying new rectifiers, check the d-c resistance to ground of the load circuit as seen by the rectifiers. If this value is correct and the trouble still persists with new rectifier tubes, it is possible that some tube in the equipment is drawing excessive current, or some capacitor is breaking down only under load. This is easily checked by removing the tubes involved and leaving the rectifiers installed. If the fuses now stay in and nothing overheats, the tubes should be replaced one at a time until the trouble is located.

Excessive voltage output from the regulated voltage supplies may be caused by a defective voltage-regulator tube. A defect in the regulator circuit may cause incorrect output voltage or excessive ripple voltage, or both.

Excessive ripple voltage in the output of a rectifier may be caused by an open filter capacitor or a defective filter choke, an unbalanced rectifier tube, or an overload. An overload will cause excessive current to flow through the filter choke, thus reducing its inductance.

Filament supply troubles will be caused by a shorted output or, in rare cases, a defective transformer. Look for shorts at tube and indicator lamp sockets, shorted lugs at terminal strips, and damaged cabling.

(3) Capacitor Troubles.

(a) Oil-Filled Paper Type.

When defective these capacitors are usually shorted. Sometimes they will break down when voltage is applied, but when the voltage is removed, they will test perfect on a resistance or capacity check. A d-c voltmeter of suitable range inserted in series with the connections to one of the capacitor terminals will serve to identify this type of failure.

(b) Mica or Ceramic Type.

When defective these capacitors may be completely shorted but often are either open or partially shorted; that is, they show an internal resistance of from zero to several hundred thousand ohms.

(c) Electrolytic Type.

When defective these capacitors may be completely shorted but more often are either completely open or low in capacity. A simple check for either of these last two conditions is to place a capacitor known to be good in parallel temporarily with the suspected one. If the circuit now behaves normally, the old capacitor should be removed and tested on a capacity bridge.

f. SETTING OF INTERNAL CONTROLS. (See figure 5-2.)

All internal controls are carefully adjusted and locked at the factory. Because of parts replacement or ageing, it may be necessary to readjust some or all of the internal controls. The recommended procedure is as follows.

(1) 300 Volt Adjust Control R70.

Connect the voltmeter between pin 12 of Jack J6 and chassis. Adjust the output voltage of the 300-volt power supply by means of R70 to 300 ±5 volts.

NOTE

The value of the power-supply output voltage affects the mean range of the two discriminator zero-set controls. If the supply voltage deviates too far from 300, it may be found that the range of the discriminator zero-set controls is displaced so they cannot be set properly. R70 is required because of variations in the operating potential of Type 5651 voltage reference tubes.

(2) Base-Line Potentiometer Slope Set Control R37.

Connect the voltmeter across the winding of BASE-LINE Control R34. Adjust R37 to give a reading of 100 volts.

NOTE

This setting largely determines the absolute accuracy of both the base-line and channel-width dial readings. If highest accuracy is desired, correct for the current drawn by the voltmeter.

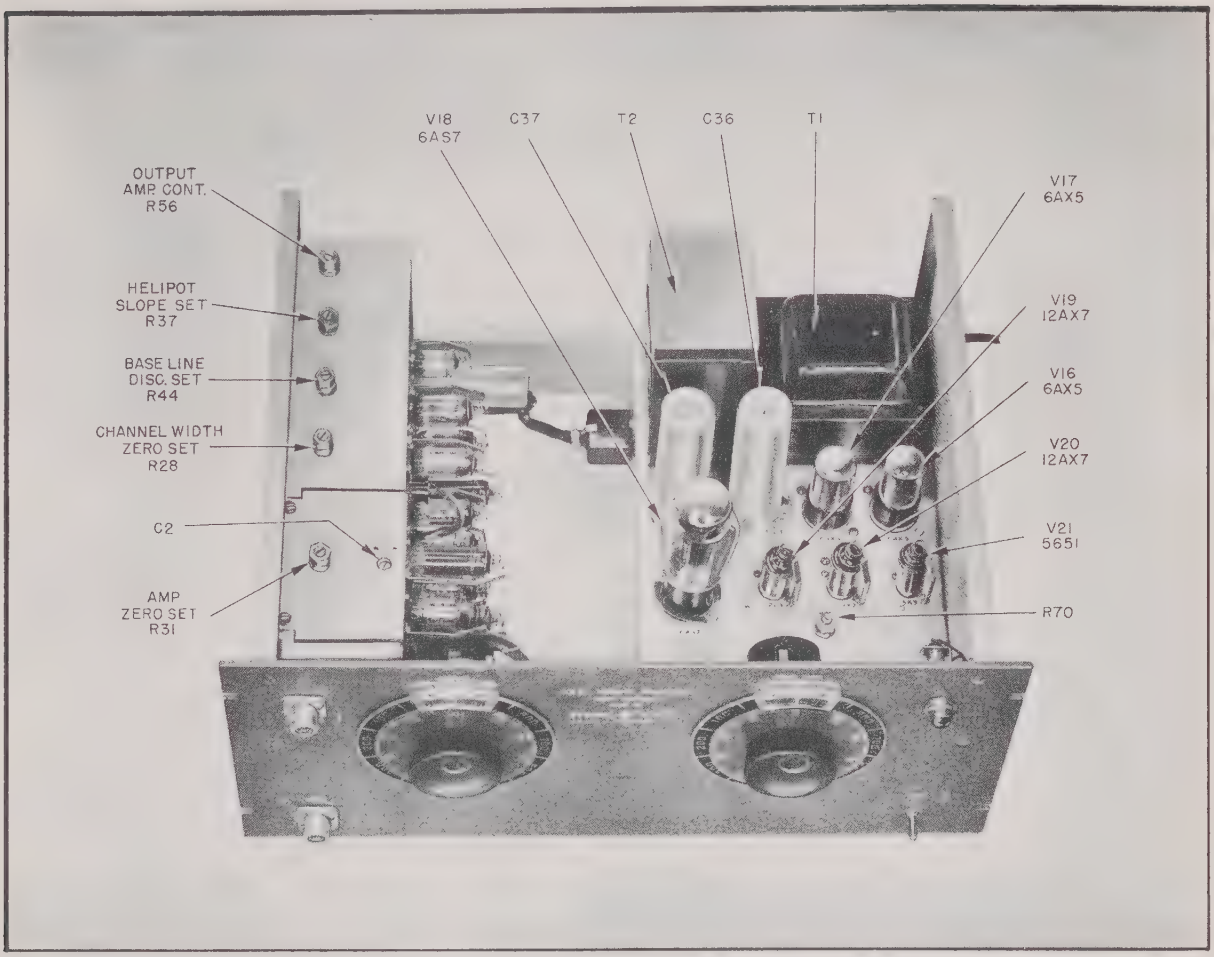


Figure 5-2. Model 510, Front and Top Oblique View: Location of Components.

(3) Capacitor C2.

Set the BASE-LINE Control R34 at 100 volts (1000 dial divisions). Supply through the linear amplifier an input pulse to the Model 510 of approximately 80 volts amplitude. Connect an oscilloscope between pin 5 of V2 and ground. Adjust C2 until the observed feed-through pulse is at a minimum.

(4) Base-Line Discriminator Zero-Set Control R44.

Feed an input pulse of any convenient amplitude through the linear amplifier used with the Model 510. Connect an oscilloscope to the junction of C17 and C25. Adjust the BASE-LINE Control R34 until the observed expander-amplifier output pulse has an amplitude of approximately five volts. Transfer the oscilloscope to pin 5 of V12. Then reduce the resistance of R44 from maximum until the base-line discriminator triggers reliably.

(5) Capacitor C20.

Feed an input pulse of any convenient amplitude through the linear amplifier as in (4) above. Connect an oscilloscope to the junction of C17 and C25, and adjust the BASE-LINE Control R34 until the expander amplifier output pulse approaches saturation.

Set the CHANNEL WIDTH Control R36 at 10 volts (1000 divisions), and move the oscilloscope to pin 5 of V10. Adjust C20 for optimum cancellation of the small spurious pulse observed.

(6) Channel-Width Zero-Set Control R28.

Set the CHANNEL-WIDTH Control R36 at zero, and connect an oscilloscope to pin 5 of V12. With an input pulse of convenient amplitude, adjust the BASE-LINE Control R34 so that the base-line discriminator barely triggers reliably. Move the oscilloscope to pin 5 of V10; then reduce the resistance of R28 from maximum until the channel-width discriminator likewise barely triggers reliably.

Check at OUTPUT Jack J2 that there is no output pulse regardless of input pulse amplitude or setting of the BASE-LINE Control R34. If output pulses are observed, R28 must be slightly readjusted.

(7) Expander-Amplifier Gain Capacitor C9.

Adjust C9 until the channel width as observed on the base-line dial agrees with the readings of the channel width dial. For this condition the oscilloscope is connected to the analyzer output and the pulse source is connected to the analyzer input. C9 should be adjusted for a channel width of five volts for the first check. This same procedure mentioned above is used to check the setting of C9 for other convenient values of channel width and for various values of input pulse amplitude.

(8) Base-Line Zero-Set Control R31.

An input pulse having an accurately known amplitude is supplied to the analyzer. The base-line control R34 is set to this value which is preferably two volts. With the oscilloscope connected to the analyzer output and the channel width control R36 set to maximum, adjust R31 until an output pulse barely appears.

(9) Output Amplitude Control R56.

Set R56 for an output amplitude which adequately drives the following equipment. The control should not be advanced further than necessary in order to limit noise caused by partial anti-coincidence. Observation of the output pulse by means of an oscilloscope connected to OUTPUT Jack J2 may be helpful.

4. PREVENTIVE MAINTENANCE.

a. INSPECTION AND CLEANING.

A periodic visual inspection and an electrical check using Table II, Voltage and Resistance Measurements, is recommended wherever a failure would represent a serious inconvenience or failure of an important experiment. Variations up to 10 per cent of nominal may usually be regarded as normal. Variations beyond this may be a warning of possible future trouble.

It is important that electronic equipment be kept clean. The chassis and component boards are best cleaned with a small paint brush and clean cloths. A cloth moistened with pure carbon tetrachloride may be used to clean metal surfaces; polish them finally with a dry cloth. Oil and dust should be cleaned out thoroughly both inside and outside the unit.

CAUTION

Compressed air should be used cautiously to avoid damage to the equipment.

Tubes and plugs should be removed from their sockets periodically and the pins inspected. Any dirt or corrosion should be removed from the pins with crocus cloth and from socket contacts with the round blade of a standard burnishing tool. This tool is impregnated with diamond dust and will not damage the socket contacts.

A clean dry cloth will usually suffice to remove dust from tubes. Be sure to clean tubes regularly because a layer of dust interferes with heat radiation and raises the operating temperature of the envelope. When finished with cleaning a unit, make sure that all tubes are properly seated in their sockets and all tube clamps locked.

A complete visual inspection of all components in the various units of the equipment should be made at least once a year. Capacitors that are leaking should be replaced. Resistors that show evidence of overheating should be removed from the circuit (where necessary for an accurate check of resistance) and checked. A resistor should be replaced if its value is outside of tolerances or if it shows signs of damage. Resistance and voltage analysis of the associated circuit should then be made to determine and correct the cause of the overload.

Rust or corrosion spots on painted surfaces should be cleaned, sanded smooth, and covered with touch-up enamel or paint. Unpainted surfaces will not ordinarily corrode unless exposed to salt water or some other corrosive agent. Should corrosion occur, it should be cleaned off thoroughly, taking care not to let the scrapings fall into the equipment, and the spot touched up with clear varnish or lacquer. Paint or varnish should not be used too close to relay, switch, or tube-socket contacts.

Cable ends should be properly dressed to prevent short circuits or strain on the wires and lugs. Contact surfaces on ferrule fuses are subject to corrosion. Keep clean and tight in their mounting clips.

b. LUBRICATION.

All moving parts in the Model 510 are lubricated for life at all points where lubrication is needed. Further lubrication is neither necessary nor desirable.

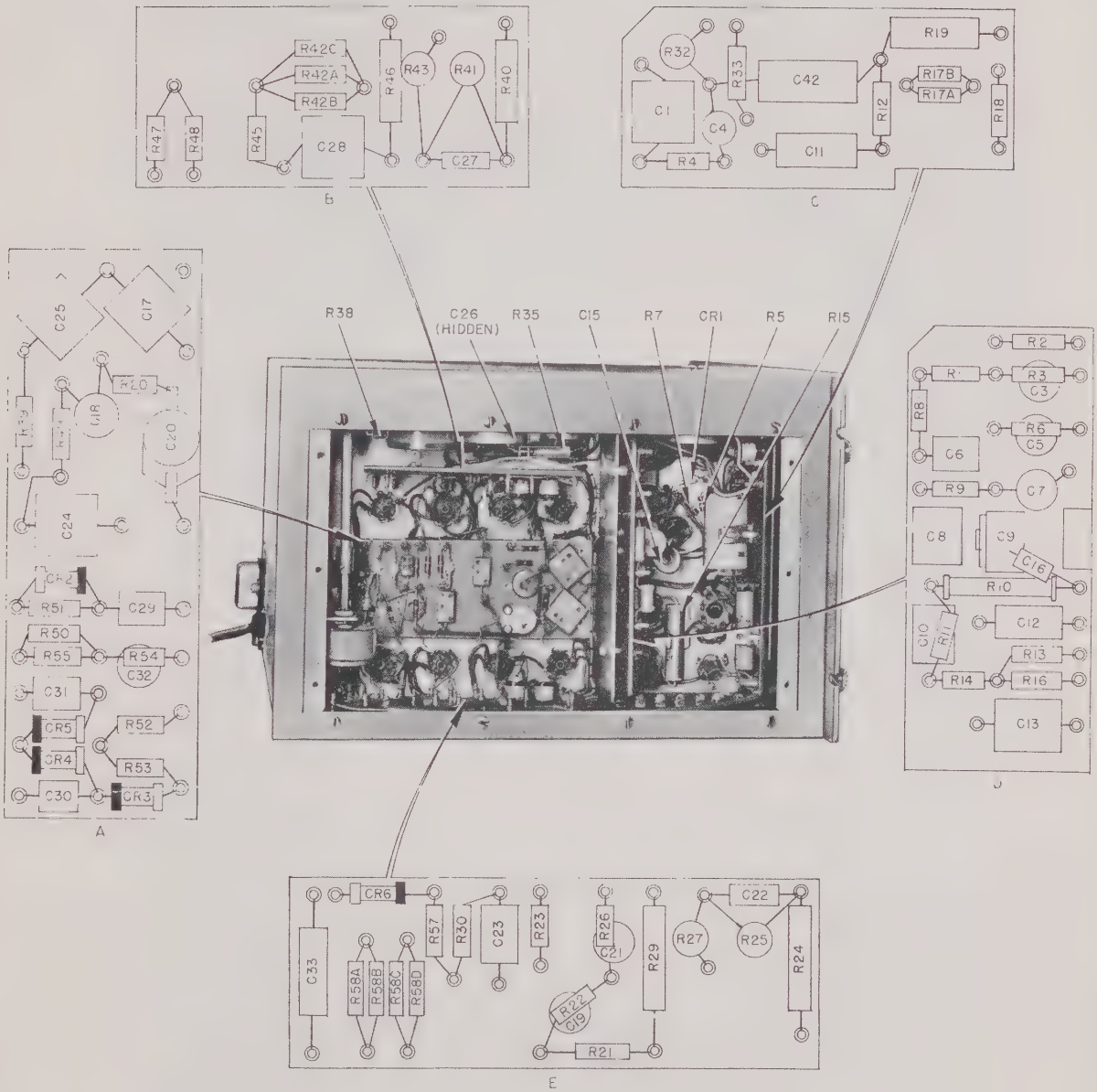


Figure 5-3. Model 510, Left-Side View with Cover Removed: Location of Components

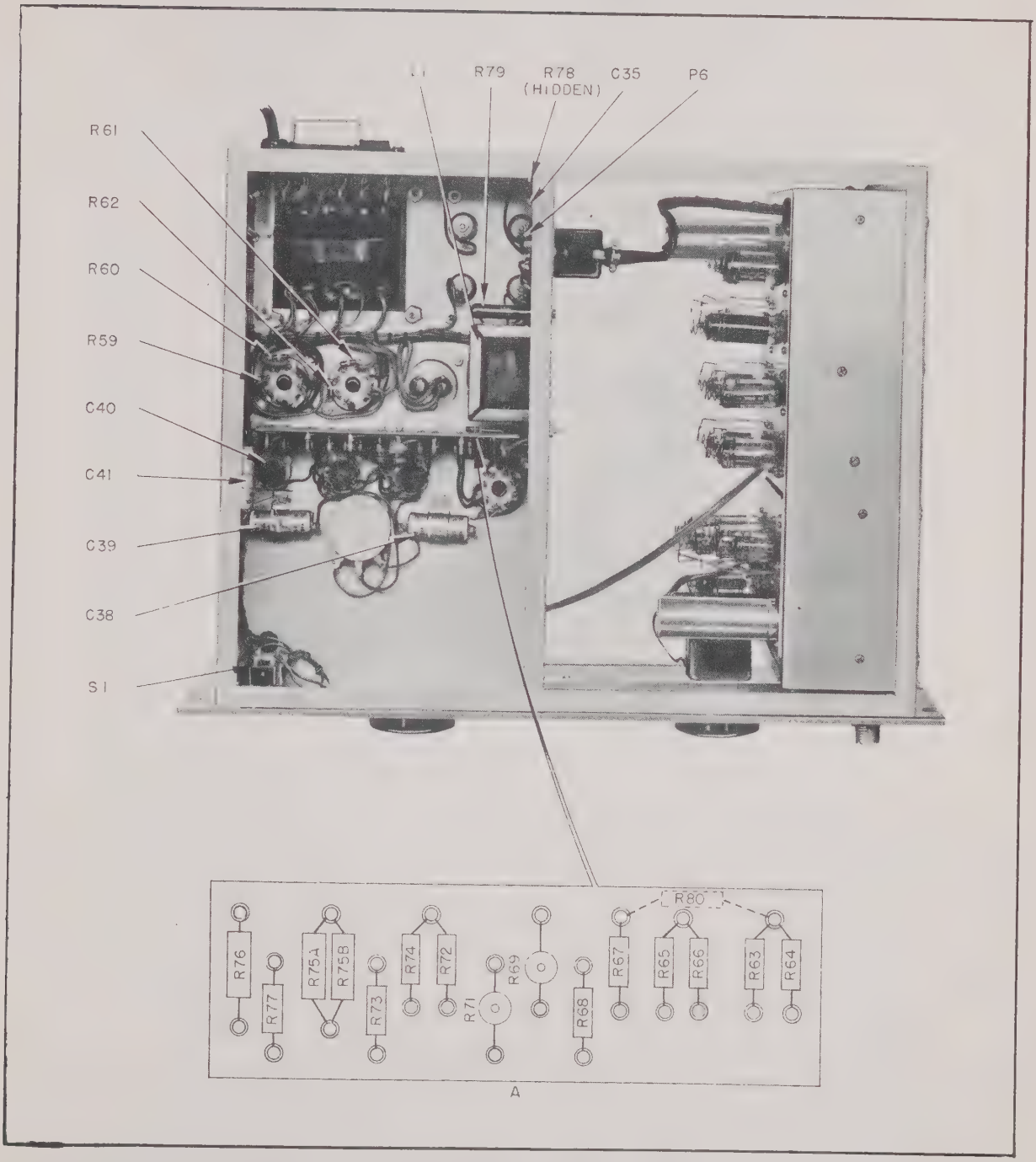


Figure 5-4. Model 510, Bottom View: Location of Components.

TABLE II. VOLTAGE AND RESISTANCE MEASUREMENTS

JACK	PIN 1	PIN 2	PIN 3	PIN 4	PIN 5	PIN 6	PIN 7	PIN 8	PIN 9
V1 6AH6	V 85 R 1.05M	V 95 R ∞	V 80 R 60K	V 80 R 60K	V 290 R 1K	V 300 R 0	V 95 R ∞	-- --	-- --
V2 6AH6	V 82 R 1.05M	V 95 R ∞	V 80 R 60K	V 80 R 60K	V 300 R 1K	V 300 R 0	V 95 R ∞	-- --	-- --
V3 6AQ5	V 20 R 52K	V 26 R 2.7K	V 80 R 60K	V 80 R 60K	V 95 R ∞	V 120 R 150K	-- --	-- --	-- --
V4 5687	V 300 R 0	V 150 R 100K	V 150 R 110K	V 80 R 60K	V 80 R 60K	V 150 R 110K	V 150 R 100K	V 80 R 60K	V 300 R 0
V5 6AG7	V 0 R 0	V 80 R 60K	V 0 R 0	V 0 R 220K	V 0 R 0	V 60 R 30K	V 80 R 60K	V 68 R 115K	-- --
V6 6AL5	V 150 R 30K	V 150 R 30K	V 80 R 60K	V 80 R 60K	V 150 R 100K	V 0 R 0	V 68 R 115K	-- --	-- --
V7 OA2	V 150 R 29K	V 0 R 0	-- --	-- --	-- --	V 0 R 0	-- --	-- --	-- --
V8 6AH6	V 84 R 1M	V 110 R ∞	V 80 R 60K	V 80 R 60K	V 297 R 2.2K	V 300 R 0	V 110 R ∞	-- --	-- --
V9 6AQ5	V 18 R 50K	V 27 R 26K	V 80 R 60K	V 80 R 60K	V 110 R ∞	V 138 R 150K	V 18 R 50K	-- --	-- --
V10 6AH6	V 108 R 75K	V 110 R ∞	V 80 R 60K	V 80 R 60K	V 270 R 3.6K	V 300 R 0	V 110 R ∞	-- --	-- --
V11 6AH6	V 84 R 1M	V 112 R 11K	V 80 R 60K	V 80 R 60K	V 296 R 2.2K	V 300 R 0	V 112 R 11K	-- --	-- --
V12 6AH6	V 110 R 75K	V 112 R 11K	V 80 R 60K	V 80 R 60K	V 275 R 2.7K	V 300 R 0	V 112 R 11K	-- --	-- --
V13 12AU7	V 300 R 0	V 0 R 1M	V 13 R 3.5K	V 80 R 60K	V 80 R 60K	V 300 R 0	V 0 R 1M	V 13 R 3.5K	V 80 R 60K
V14 6AL5	V 13 R ∞	V 13 R ∞	V 80 R 60K	V 80 R 60K	V 13 R 3.5K	-- --	V 13 R 3.5K	-- --	-- --
V15 12AU7	V 270 R 3K	V 142 R 500K	V 150 R 15K	V 80 R 60K	V 80 R 60K	V 270 R 6K	V 142 R 500K	V 150 R 15K	V 80 R 60K
V16 6AX5	-- --	V 280 R 470K	V 700 R 380	V 700 R 360	V 700 R 380	V 700 R 360	V 280 R 470K	V 415 R 470K	-- --
V17 6AX5	-- --	V 280 R 470K	V 700* R 380	V 700* R 360	V 700* R 380	V 700* R 360	V 280 R 470K	V 415 R 470K	-- --
V18 6AS7	V 250 R 470K	V 415 R 470K	V 300 R 0	V 250 R 470K	V 415 R 470K	V 300 R 0	V 290 R 470K	V 290 R 470K	-- --
V19 12AX7	V 250 R 470	V 150 R 470K	V 160 R 150K	V 80 R 60K	V 80 R 60K	V 300 R 0	V 150 R 470K	V 160 R 150K	V 80 R 60K
V20 12AX7	V 150 R 470	V 88 R 80K	V 88 R 150K	V 80 R 60K	V 80 R 60K	V 150 R 470	V 88 R 110K	V 88 R 150K	V 80 R 60K
V21 5651	-- --	V 0 R 0	-- --	-- --	V 88 R 110K	-- --	-- --	-- --	-- --

TABLE II. VOLTAGE AND RESISTANCE MEASUREMENTS (cont.)

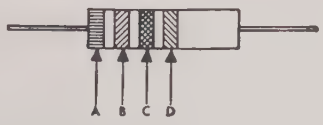
JACK	PIN 1	PIN 2	PIN 3	PIN 4	PIN 5	PIN 6	PIN 7	PIN 8	PIN 9	PIN 10	PIN 11	PIN 12
J1	V 0 R ∞	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
J2	V 1.2 R ∞	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
J3	V 0 R ∞	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
J4	V 0 R 0	V 92 R 17K	V 92 R 17K	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
J5	V 0 R 0	V 92 R 17K	V 92 R 17K	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --	-- --
J6	V 80 R 60K	V 80 R 60K	V 80 R 60K	V 80 R 60K	-- --	V 80 R 60K	-- --	-- --	-- --	V 0 R 0	-- --	V 300 R 0

Voltage measurements above are taken with all controls set at full CCW position. The exceptions to this are the Output Amplitude Control, R56, which is set to a full CW position and R70 which is put at the 300V setting. All resistances are measured to ground in ohms unless otherwise noted. All voltages are d-c voltage to ground unless otherwise noted.

* Indicates a peak to peak AC voltage.

Pin #12 - (+300 grounded)

RESISTORS — FIXED COMPOSITION



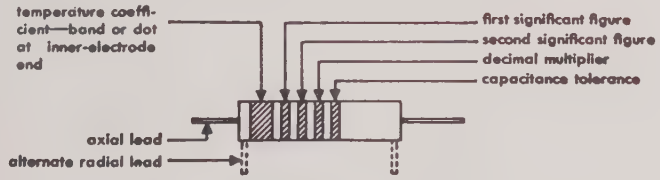
axial leads	color	radial leads
Band A	Indicates first significant figure of resistance value in ohms	Body A
Band B	Indicates second significant figure	End B
Band C	Indicates decimal multiplier	Band C or dot
Band D	If any, indicates tolerance in percent about nominal resistance value. If no color appears in this position, tolerance is 20%	Band D

RADIO – INDUSTRY COLOR CODE

color	significant figure	decimal multiplier	tolerance in percent*	voltage rating	character-istic
Black	0	1	±20 (M)	—	A
Brown	1	10	——	100	B
Red	2	100	±2 (G)	200	C
Orange	3	1,000	——	300	D
Yellow	4	10,000	——	400	E
Green	5	100,000	——	500	F
Blue	6	1,000,000	——	600	G
Violet	7	10,000,000	——	700	–
Grey	8	100,000,000	——	800	I
White	9	1,000,000,000	——	900	J
Gold	–	0.1	±5 (J)	1000	–
Silver	–	0.01	±10 (K)	2000	–
No color	–	——	±20	500	–

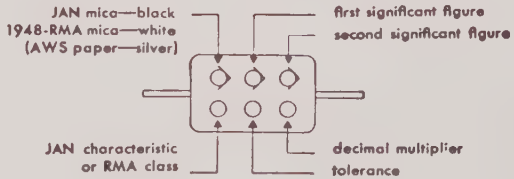
* Letter symbol is used at end of type designations in RMA standards and JAN specifications to indicate tolerance

CAPACITORS — FIXED CERAMIC



color	significant figure	decimal multiplier	capacitance tolerance: in percent (C > 10 μμf)	capacitance tolerance: in μμf (C ≤ 10 μμf)	temperature coefficient in parts/million/°C
Black	0	1	±20 (M)	——	0 (C)
Brown	1	10	±1 (F)	±0.1 (B)	—30 (H)
Red	2	100	±2 (G)	——	—80 (L)
Orange	3	1,000	——	——	—150 (P)
Yellow	4	10,000	——	——	—220 (R)
Green	5	—	±5 (J)	±0.5 (D)	—330 (S)
Blue	6	—	——	——	—470 (T)
Violet	7	—	——	——	—750 (U)
Gray	8	0.01	——	±0.25 (C)	+30
White	9	0.1	±10 (K)	1.0 (F)	+120 to —750 (RMA general purpose)
Silver	–	—	——	——	

CAPACITORS — MOLDED MICA-DIELECTRIC



CAPACITORS — MOLDED MICA-DIELECTRIC

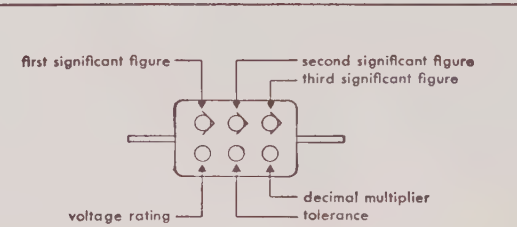


Figure 5-5. Resistor and Capacitor Color Codes.

SECTION VI
PARTS LIST

1. GENERAL.

All parts shown on the schematic diagrams, Figures 6-1 and 6-2, are listed by symbol designation and described in the parts list. In addition, the figure number on which the part is located and identified is also listed.

Manufacturers of the parts so described are identified by a manufacturer's designation in accordance with the list below.

LIST OF MANUFACTURERS

Designation	Name and Address
AMEL	Amalgamated Electronics Electronics Road Clinton Corners, N. Y.
BOEC	Bond Electronics Corp. 60 Springfield Ave. Springfield, N. J.
CAW	Aerovox Corp. 742 Belleville Ave. New Bedford, Mass.
CBPF	Baird-Atomic, Inc. 33 University Road Cambridge 38, Mass.
CBZ	Allen-Bradley Co. 136 W. Greenfield Ave. Milwaukee, Wis.
CCC	Continental Carbon, Inc. 13900 Lorain Ave. Cleveland 11, Ohio
CD	Cornell-Dubilier Electric Corp. South Plainfield, N. J.
CGF	The Gudeman Co. 361 W. Superior St. Chicago 10, Ill.
CHH	Arrow-Hart & Hegeman Electric Co. 100 Hawthorne St. Hartford 6, Conn.
CHS	The Chase-Shawmut Co. Newburyport, Mass.
CIR	International Resistance Corp. 401 N. Broad St. Philadelphia, Pa.
CMA	P. R. Mallory & Co., Inc. 3029 E. Washington St. Indianapolis 6, Ind.
CMF	The Electro Motive Mfg. Co., Inc. Willimantic, Conn.
CMG	Cinch Mfg. Co. Dover, N. H.
COI	Cords, Ltd. Div. Essex Wire Corp. 121 Dodge St. DeKalb, Ill.
CPH	American Phenolic Corp. 1830 S. 54th Ave. Chicago 50, Ill.
CSF	Sprague Electric Co. N. Adams, Mass.
CSY	Crosley Div. Avco Mfg. Corp. Cincinnati 25, Ohio
GBE	Centralab Div. of Globe-Union Inc. 914 E. Keefe Ave. Milwaukee 1, Wis.
GE	General Electric Co. Lamp Div. Nela Park Cleveland 12, Ohio
HPT	Helipot Corp. 916 Meriden Ave. South Pasadena, Calif.
LTF	Littelfuse, Inc. 4757 N. Ravenswood Chicago, Ill.
MODE	Model Engineering & Mfg., Inc. Huntington, Ind.

PARTS LIST

MODEL 510 SINGLE-CHANNEL PULSE HEIGHT ANALYZER

Symbol Designation	Description	Figure No.	Mfg. No. or Type	Manufacturer
C1	1000 mmf, mica, 500v.	5-3 (C)*	CM20B102K	CMF
C2	5-25 mmf, ceramic.	5-2	822-AZ	GBE
C3	0.01 mf, ceramic disc, 600v.	5-3 (D)*	DD-103	GBE
C4	0.01 mf, ceramic disc, 600v.	5-3 (C)*	DD-103	GBE
C5	0.01 mf, ceramic disc, 600v.	5-3 (D)*	DD-103	GBE
C6	1000 mmf, mica, 500v.	5-3 (D)*	CM20B102K	CMF
C7	0.01 mf, ceramic disc, 600v.	5-3 (D)*	DD-103	GBE
C8	0.01 mf, mica, 500v.	5-3 (D)*	CM35B103K	CMF
C9	5-25 mmf, ceramic.	5-3 (D)*	822-AZ	GBE
C10	68 mmf, mica, 500v.	5-3 (D)*	CM15C680J	CMF
C11	0.1 mf, paper, 600v.	5-3 (C)*	MBC6P1	CD
C12	100 mmf, mica, 500v.	5-3 (D)*	CM15C101J	CMF
C13	0.01 mf, mica, 500v.	5-3 (D)*	CM35B103K	CMF
C14	2 sections, 20 mf, 20 mf; 450v.	5-1	FP234	CMA
C15	0.01 mf, ceramic disc, 600v.	5-3	DD-103	GBE
C16	22 mmf, mica, 500v.	5-3 (D)*	CM15C220J	CMF
C17	0.01 mf, mica, 500v.	5-3 (A)*	CM35B103K	CMF
C18	0.01 mf, ceramic disc.	5-3 (A)*	DD-103	GBE
C19	0.01 mf, ceramic disc.	5-3 (E)*	DD-103	GBE
C20	5-25 mmf, ceramic.	5-3 (A)*	822-AZ	GBE
C21	0.01 mf, ceramic disc.	5-3 (E)*	DD-103	GBE
C22	33 mmf, mica, 500v.	5-3 (E)*	CM15C330J	CMF
C23	1000 mmf, mica, 500v.	5-3 (E)*	CM20B102K	CMF
C24	1000 mmf, mica, 500v.	5-3 (A)*	CM20B102K	CMF
C25	0.01 mf, mica, 500v.	5-3 (A)*	CM35B103K	CMF
C26	0.01 mf, oil-filled paper, 600v.	5-3	OTB-88101	CGF
C27	33 mmf, mica, 500v.	5-3 (B)*	CM15C330J	CMF
C28	1000 mmf, mica, 500v.	5-3 (B)*	CM20B102K	CMF
C29	560 mmf, mica, 500v.	5-3 (A)*	CM20B561K	CMF
C30	100 mmf, mica, 500v.	5-3 (A)*	CM15C101J	CMF
C31	100 mmf, mica, 500v.	5-3 (A)*	CM15C101J	CMF
C32	0.01 mf, ceramic disc, 600v.	5-3 (A)*	DD-103	GBE
C33	0.01 mf, paper, 400v.	5-3 (E)*	30411	
C34	2 sections, 20 mf, 20 mf; elec; 450v.	5-1	FP234	CMA
C35	0.01 mf, ceramic disc, 600v.	5-4	DD-1032	GBE
C36	4.0 mf, oil filled, 600v.	5-2	CRG3040-1	CD
C37	4.0 mf, oil filled, 600v.	5-2	CRG3040-1	CD
C38	0.1 mf, oil-filled paper, 600v.	5-4	OTB-88101	CGF
C39	0.1 mf, oil-filled paper, 600v.	5-4	OTB-88101	CGF
C40	0.01 mf, ceramic disc.	5-4	DD-103	GBE
C41	0.1 mf, oil-filled paper, 600v.	5-4	OTB-88101	CGF
C42	20 mf, dry electrolytic, 450v.	5-3 (C)*	PRS	CAW
CR1	Crystal, germanium, 1N34A.	5-3	1N34A	CHS
CR2	Crystal, germanium, 1N34A.	5-3 (A)*	1N34A	CHS
CR3	Crystal, germanium, 1N34A.	5-3 (A)*	1N34A	CHS
CR4	Crystal, germanium, 1N34A.	5-3 (A)*	1N34A	CHS
CR5	Crystal, germanium, 1N34A.	5-3 (A)*	1N34A	CHS
CR6	Crystal, germanium, 1N34A.	5-3 (E)*	1N34A.	CHS
F1	3.0 amp. 125v, time delay.	5-1	3AG	LTF
F2	3.0 amp, 125v, time delay.	5-1	3AG	LTF

NOTE: ( ) * following a figure number indicates the part is located on a panel board designated by the letter enclosed in parenthesis.

PARTS LIST

MODEL 510 SINGLE-CHANNEL PULSE HEIGHT ANALYZER (CONT.)

Symbol Designation	Description	Figure No.	Mfg.. No. or Type	Manufacturer
I1	Lamp; 6.3v, 0.15 amp.	3-1	#47	GE
J1	Coaxial connector; female.	3-1	83-1R	CPH
J2	Coaxial connector; female.	3-1	83-1R	CPH
J3	Convenience outlet.	5-1	12844	CMG
J4	Connector; 3 pin, female.	5-1	78-S3S	CPH
J5	Connector; 3 pin, female.	5-1	78-S3S	CPH
J6	Connector; 12 pin, female.	5-4	S-312-AB	CMG
L1	Choke; 3.5 hy at 125 ma.	5-4	LF-4	CBPF
P1	Line cord and plug.	3-1	E-712	COI
P4	Connector; 3 pin, male.	5-1	71-3S	CPH
P5	Connector; 3 pin, male.	5-1	71-3S	CPH
P6	Connector; 12 pin, male.	5-4	P-312-CCT	CMG
R1	820k, ±10%; 1/2W; comp.	5-3 (D)*	EB8241	CBZ
R2	220 ohms, ±10%; 1/2W; comp.	5-3 (D)*	EB2211	CBZ
R3	56k, ±10%; 1/2W; comp.	5-3 (D)*	EB5631	CBZ
R4	1.0 meg, ±10%; 1/2W; comp.	5-3 (C)*	EB1051	CBZ
R5	1000 ohms, ±10%; 1/2W; comp.	5-3	EB1021	CBZ
R6	2700 ohms, ±10%; 1/2W; comp.	5-3	EB2721	CBZ
R7	1000 ohms, ±10%; 1/2W; comp.	5-3	EB1021	CBZ
R8	150k, ±10%; 1/2W; comp.	5-3 (D)*	EB1541	CBZ
R9	1.0 meg, ±10%; 1/2W; comp.	5-3 (D)*	EB1051	CBZ
R10	100k, ±1%; 1W; film type.	5-3 (D)*	X-1	CCC
R11	11k, ±1%; 1/2W; film type.	5-3 (D)*	X-1/2	CCC
R12	220k, ±10%; 1W; comp.	5-3 (C)*	GB2241	CBZ
R13	100 ohms, ±10%; 1/2W; comp.	5-3 (D)*	EB1011	CBZ
R14	100k, ±10%; 1/2W; comp.	5-3 (D)*	EB1041	CBZ
R15	3000 ohms, 10W; wire wound.	5-3	10N1T	CSF
R16	100 ohms, ±10%; 1/2W; comp.	5-3 (D)*	EB1011	CBZ
R17A	56k, ±10%; 1W; comp.	5-3 (C)*	EB5631	CBZ
R17B	56k, ±10%; 1W; comp.	5-3 (C)*	EB5631	CBZ
R18	1000 ohms, ±10%; 1/2W; comp.	5-3 (C)*	EB1021	CBZ
R19	30k, 10W; wire wound.	5-3 (C)*	10KT	CSF
R20	1.0 meg, ±10%; 1/2W; comp.	5-3 (A)*	EB1051	CBZ
R21	820k, ±10%; 1/2W; comp.	5-3 (E)*	EB8241	CBZ
R22	56k, ±10%; 1/2W; comp.	5-3 (E)*	EB5631	CBZ
R23	220 ohms, ±10%; 1/2W; comp.	5-3 (E)*	EB2211	CBZ
R24	2200 ohms, ±10%; 1W; wire wound.	5-3 (E)*	BW-1	CIR
R25	200k, ±1%; wire wound.	5-3 (E)*	203	BOEC
R26	2700 ohms, ±10%; 1/2W; comp.	5-3 (E)*	EB2721	CBZ
R27	100k, ±1%; wire wound.	5-3 (E)*	203	BOEC
R28	15k, ±10%; 2W; variable; wire wound.	5-2	CV15MP	CMA
R29	3600 ohms, ±5%; 1W; wire wound.	5-3 (E)*	BW-1	CIR
R30	150k, ±10%; 1/2W; comp.	5-3 (E)*	EB1541	CBZ
R31	10k, ±10%; 4W; variable; wire wound.	5-2	M10MP	CMA
R32	250k, ±1%; wire wound.	5-3 (C)*	203	BOEC
R33	1000 ohms, ±10%; 1W; wire wound.	5-3 (C)*	BW-1	CIR
R34	Helipot, 50k, 0.5% linearity.	3-1	Model A	HPT
R35	1000 ohms, ±10%; 1W; wire wound.	5-3	BW-1	CIR

NOTE: ( ) * following a figure number indicates the part is located on a panel board designated by the letter enclosed in parenthesis.

PARTS LIST

MODEL 510 SINGLE-CHANNEL PULSE HEIGHT ANALYZER (CONT.)

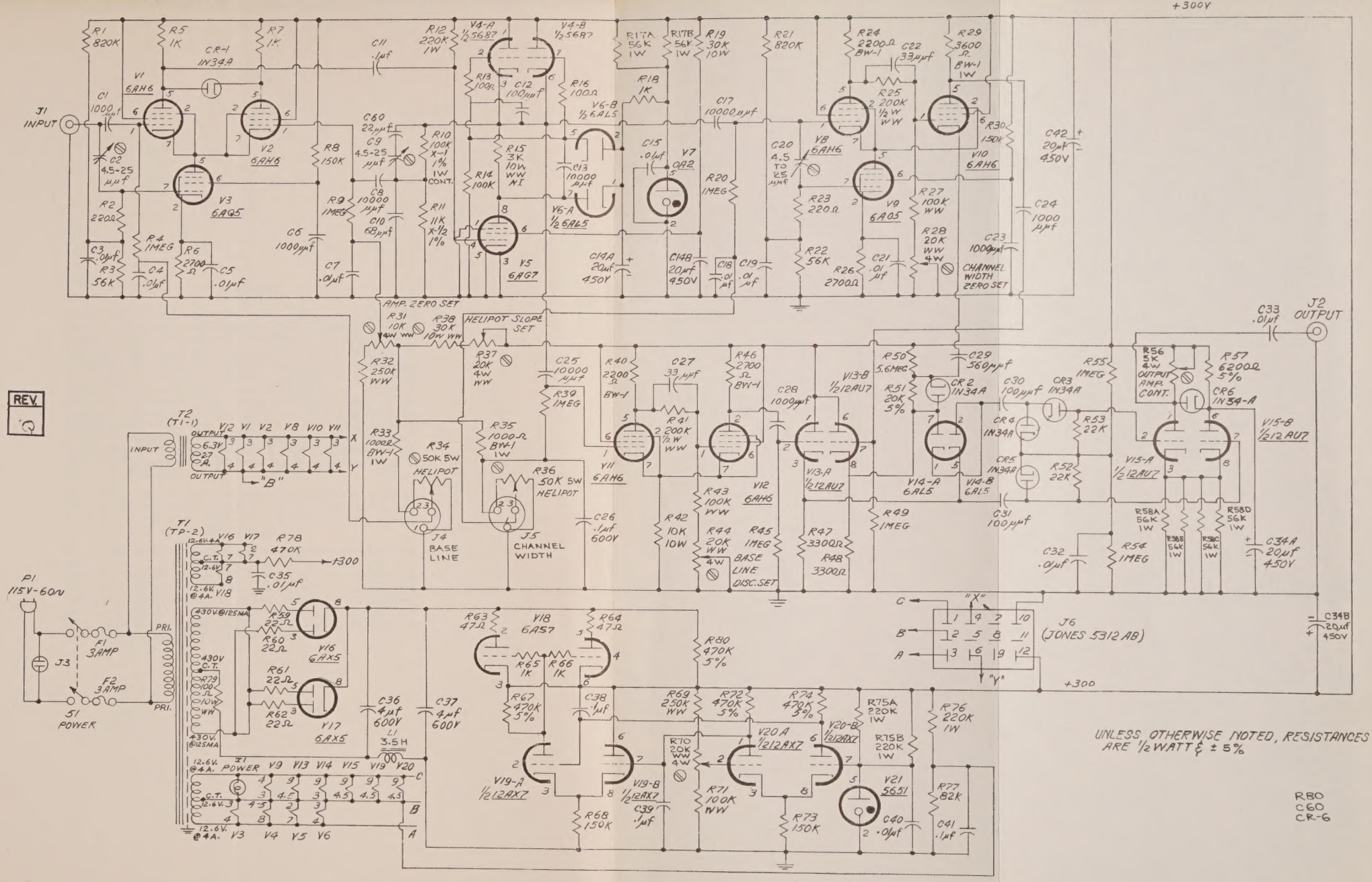
Symbol Designation	Description	Figure No.	Mfg. No. or Type	Manufacturer
R36	Helipot, 50k, 0.5% linearity.	3-1	Model A	HPT
R37	20k, ±10%; 4W; variable; wire wound.	5-2	PRA-30	AMEL
R38	30k, 10W, wire wound.	5-3	10 KT	CSF
R39	1.0 meg, ±10%; 1/2W.	5-3 (A)*	EB1051	CBZ
R40	2200 ohms, ±10%; 1W; wire wound.	5-3 (B)*	BW-1	CIR
R41	200k, ±1%; wire wound.	5-3 (B)*	203	BOEC
R42A	33k, ±10%; 1/2W; comp.	5-3 (B)*	EB3331	CBZ
R42B	33k, ±10%; 1/2W; comp.	5-3 (B)*	EB3331	CBZ
R42C	33k, ±10%; 1/2W; comp.	5-3 (B)*	EB3331	CBZ
R43	100k, wire wound.	5-3 (B)*	203	BOEC
R44	20k, ±10%; 4W; variable; wire wound.	5-2	M20MP	CMA
R45	1.0 meg, ±10%; 1/2W; comp.	5-3 (B)*	EB1051	CBZ
R46	2700 ohms, ±10%; 1W; wire wound.	5-3 (B)*	BW-1	CIR
R47	3300 ohms, ±10%; 1/2W; comp.	5-3 (B)*	EB3321	CBZ
R48	3300 ohms, ±10%; 1/2W; comp.	5-3 (B)*	EB3321	CBZ
R49	1.0 meg, ±10%; 1/2W; comp.	5-3 (A)*	EB1051	CBZ
R50	5.6 meg, ±10%; 1/2W; comp.	5-3 (A)*	EB5651	CBZ
R51	20k, ±5%; 1/2W; comp.	5-3 (A)*	EB2035	CBZ
R52	22k, ±10%; 1/2W; comp.	5-3	EB2231	CBZ
R53	22k, ±10%; 1/2W; comp.	5-3	EB2231	CBZ
R54	1.0 meg, ±10%; 1/2W; comp.	5-3 (A)*	EB1051	CBZ
R55	1.0 meg, ±10%; 1/2W; comp.	5-3 (A)*	EB1051	CBZ
R56	5k, ±10%; 4W; variable; wire wound.	5-2	PRA-30	AMEL
R57	6200 ohms, ±5%; 1/2W; comp.	5-3 (E)*	EB6225	CBZ
R58A	56k, ±10%; 1W; comp.	5-3 (E)*	GB5631	CBZ
R58B	56k, ±10%; 1W; comp.	5-3 (E)*	GB5631	CBZ
R58C	56k, ±10%; 1W; comp.	5-3 (E)*	GB5631	CBZ
R58D	56k, ±10%; 1W; comp.	5-3 (E)*	GB5631	CBZ
R59	22 ohms, ±10%; 1/2W; comp.	5-4	EB2201	CBZ
R60	22 ohms, ±10%; 1/2W; comp.	5-4	EB2201	CBZ
R61	22 ohms, ±10%; 1/2W; comp.	5-4	EB2201	CBZ
R62	22 ohms, ±10%; 1/2W; comp.	5-4	EB2201	CBZ
R63	47 ohms, ±10%; 1/2W; comp.	5-4 (A)*	EB4701	CBZ
R64	47 ohms, ±10%; 1/2W; comp.	5-4 (A)*	EB4701	CBZ
R65	1000 ohms, ±10%; 1/2W; comp.	5-4 (A)*	EB1021	CBZ
R66	1000 ohms, ±10%; 1/2W; comp.	5-4 (A)*	EB1021	CBZ
R67	470k, ±5%; 1/2W; comp.	5-4 (A)*	EB4745	CBZ
R68	150k, ±10%; 1/2W; comp.	5-4 (A)*	EB1541	CBZ
R69	250k, ±1%; wire wound.	5-4 (A)*	203	BOEC
R70	10k, ±10%; 4W; wire wound.	5-2	M20MP	CMA
R71	100k, ±1%; wire wound.	5-4 (A)*	203	BOEC
R72	470k, ±5%; 1/2W; comp.	5-4 (A)*	EB4745	CBZ
R73	150k, ±10%; 1/2W; comp.	5-4 (A)*	EB1541	CBZ
R74	470k, ±5%; 1/2W; comp.	5-4 (A)*	EB4745	CBZ
R75A	220k, ±10%; 1W; comp.	5-4 (A)*	GB2241	CBZ
R75B	220k, ±10%; 1W; comp.	5-4 (A)*	GB2241	CBZ
R76	220k, ±10%; 1W; comp.	5-4 (A)*	GB2241	CBZ
R77	82k, ±10%; 1/2W; comp.	5-4 (A)*	EB8231	CBZ
R78	470k, ±10%; 1/2W; comp.	5-4	EB4741	CBZ
R79	200 ohms, 10W; wire wound.	5-4	FRL-10	MODE
R80	470k, ±5%; 1/2W; comp.	5-4 (A)*	EB4745	CBZ

NOTE: ( ) * following a figure number indicates the part is located on a panel board designated by the letter enclosed in parenthesis.

PARTS LIST

MODEL 510 SINGLE-CHANNEL PULSE HEIGHT ANALYZER (CONT.)

Symbol Designation	Description	Figure No.	Mfg. No. or Type	Manufacturer
S1	Switch; DPDT.	5-4	80127CE	CHH
T1	Plate and filament transformer; 12.6v center tapped at 4 amp, 12.6v center tapped at 4 amp, 860v center tapped.	5-2	TP-2	CBPF
T2	Filament Transformer; 6.3v at 2.7 amp.	5-2	30785	CSY
V1	6AH6, sharp-cutoff pentode.	5-1	6AH6	
V2	6AH6, sharp-cutoff pentode.	5-1	6AH6	
V3	6AQ5, beam-power amplifier.	5-1	6AQ5	
V4	5687, twin triode.	5-1	5687	
V5	6AG7, power pentode.	5-1	6AG7	
V6	6AL5, twin diode.	5-1	6AL5	
V7	OA2, voltage regulator.	5-1	OA2	
V8	6AH6, sharp-cufoff pentode.	5-1	6AH6	
V9	6AQ5; beam-power amplifier.	5-1	6AQ5	
V10	6AH6, sharp-cutoff pentode.	5-1	6AH6	
V11	6AH6, sharp-cutoff pentode.	5-1	6AH6	
V12	6AH6, sharp-cutoff pentode.	5-1	6AH6	
V13	12AU7, twin-triode amplifier.	5-1	12AU7	
V14	6AL5, twin diode.	5-1	6AL5	
V15	12AU7, twin-triode amplifier.	5-1	12AU7	
V16	6AX6, full-wave vacuum rectifier.	5-2	6AX5	
V17	6AX5, full-wave vacuum rectifier.	5-2	6AX5	
V18	6AS7, low-mu twin-power triode.	5-2	6AS7	
V19	12AX7, high-mu twin triode.	5-2	12AX7	
V20	12AX7, high-mu twin triode.	5-2	12AX7	
V21	5651, voltage reference tube.	5-2	5651	



UNLESS OTHERWISE NOTED, RESISTANCES ARE ½ WATT ℄ ± 5%

NOTE:

Schematic separately enclosed supersedes this if a later revision is indicated.

SCHEMATIC – SINGLE CHANNEL PULSE HEIGHT ANALYZER 60 CYCLE, 115 VOLT MODEL 510-BASIC

WARRANTY

Baird-Atomic, Inc. (the "Company"), warrants this equipment for a period of 1 year from the date of shipment as follows: it warrants that all equipment of its manufacture is free from defects in material and workmanship at the time of shipment. If within 1 year of shipment any equipment of the Company's manufacture develops defects in material or workmanship under normal conditions of operation, the buyer of the equipment may return it to the Company within 30 days of such failure, for repairs at the expense of the Company, including the expense of shipment, or in the case of any defective part may return such part to the Company which will repair or replace the same at its expense, including the cost of shipment. A further warranty of 1 year on the same terms shall be applicable to any part so repaired or replaced. Except for Dekatron glow tubes, this warranty does not extend to stock components not manufactured by the Company.

The Company shall not be liable for damage or destruction of instruments during delivery or caused by other than employees of Baird-Atomic, Inc.; in any event, liability shall not exceed the cost of replacement of defective parts upon prompt notification of such defect.

For return of equipment or any part thereof under the terms of the foregoing warranty a letter should be forwarded to Baird-Atomic, Inc., Attention: Sales Service Department, 33 University Road, Cambridge 38, Massachusetts. It should state owner's name and address; model and serial number of the equipment; the order number, under which it was purchased; the date of failure and a description of the circumstances surrounding same. Upon receipt of such information, shipping instructions for return of equipment or parts thereof will be forwarded promptly.

Baird-Atomic, Inc.

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